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Autoclaved aerated concrete : shaping the evolution of residential construction in the United States.

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Autoclaved Aerated Concrete: Shaping the Evolution of Residential Construction in the United States

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Executive Summary

Precast Autoclaved Aerated Concrete (AAC) is a proven construction material used successfully in Europe for over 70 years. Introduced to the United States construction market in 1990, construction thus far has been limited to commercial and high end custom home applications. The world leading manufacturer and distributor of AAC products is *Hebel*, of Germany. To establish their presence in the United States, *Hebel* primarily focused its resources and marketing efforts on the more lucrative commercial market. With the onset of emerging competition, continued corporate growth and strength is dependent upon penetration into the mainstream residential construction market.

Despite AAC being the leading residential construction material in Europe and Japan, lumber is the leading material of choice in the United States. AAC's selling points of low life cycle costs, energy efficiency, superior fire resistance, acoustic efficiency, and natural resource conservation are not enough to justify the additional cost associated with this product's present form and installation methods. The major market is so competitive that just a slight price increase could mean loss of market share. Builders are simply not willing to take this risk when consumers are content buying lumber homes.

In an effort to promote the use of AAC in U.S. residential construction, this research effort introduces aerated concrete as an alternative to traditional residential construction methods, reports the state of the AAC industry, and surveys home buyer preferences and opinions. A comparison of consumer and builder needs to current AAC product form and installation methods identifies technical and marketing issues that can be incorporated into modified products that better accommodate the U.S. residential industry. Sustained use of alternative construction materials defends consumers against rising costs of home ownership resulting from dependence on any single dominant building material.

Autoclaved aerated concrete is clearly a superior residential construction product in its current form. However, the competitive nature of home construction in the U.S., the economic position of lumber, and industry change hesitation demand a different marketing approach than is used in AAC construction elsewhere in the world. Every consumer and builder would like to have all the benefits AAC provides, but are not necessarily willing to accept significantly higher costs or change the way building trades construct homes. Two options to make AAC more appealing to U.S. residential construction are product modification and cost improvements. The key to product modification is the ability of the product to meet the needs of consumers and builders.

Using an innovative internet-based survey, 693 potential home buyers answered a 9 step questionnaire as a basis to provide data surrounding three core issues: what characteristics of a house are important to the consumer, how much are consumers willing to pay for superior characteristics or benefits, and at what payback rate for premium benefits are acceptable.

The survey results show that energy savings, maintenance costs, and disaster resistance are all very important issues to home buyers. Regardless of assigned rankings, over 90% of buyers

reported they would pay more for a home that incorporated even one of these features. Over 85% of buyers would spend more than $1,500 each for energy savings and disaster resistance features. The survey shows the majority willingness of consumers to spend more for superior benefits, and subsequently for construction products featuring those benefits.

Using the detailed survey analysis, interviews with construction industry professionals, and current product capabilities, the AAC industry can tailor its products to squarely meet the needs of residential construction. Through adaptation of current product form, application, and construction methods, AAC can be cost competitive with traditional residential construction methods.

The final phase of the evolution is to educate consumers and builders. Consumers' willingness to spend extra for premium benefits is contingent on understanding the connection between building products and their benefits, how much they are paying for them, and the life cycle cost savings they will receive in return.

As AAC construction becomes more commonplace, it will be considered by builders and consumers as a conventional material and construction method. Moreover, this technology will provide consumers a long overdue option to lumber construction. Not only will consumers benefit from low utility and life cycle costs, but the environment will benefit from its energy efficiency and natural resource conservation.

Autoclaved Aerated Concrete: Shaping the Evolution of Residential Construction in the United States

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Abstract: Precast Autoclaved Aerated Concrete (AAC) is a proven construction material used in Europe for over 70 years. Introduced to the United States in 1990, construction thus far is limited to commercial and custom home applications. Premium benefits include energy efficiency and resistance to natural disaster and pests. Despite being the leading residential construction material in Europe and Japan, lumber is the leading material of choice in the United States. AAC is clearly a superior residential construction product in its current form, but the economic position of lumber and industry change hesitation demand a different marketing approach than is used elsewhere in the world. Using an internet-based survey, home buyers provide data surrounding three core issues: the important characteristics of a house, how much are they willing to pay for superior benefits, and the expected payback period. Adapting current product form and installation methods can make AAC cost competitive with traditional residential framing systems. Consumer education is essential in this evolution to understand the connection between building products and their benefits. As an option to lumber construction, consumers will benefit from its low utility and life cycle costs. The environment will benefit from its energy efficiency and natural resource conservation.

Introduction

In 1990, *Hebel* of Germany introduced North America to Precast Autoclaved Aerated Concrete (AAC) as an alternative structural construction system. The *Hebel* Construction System is a complete structural building system designed for low rise commercial and residential applications. Although innovative to the United States construction industry, AAC is a proven material in use for over 70 years in Europe. Since its commercial production beginning in 1923, AAC has been used to build millions of residences worldwide. As an alternative to traditional residential construction methods, AAC not only provides consumers and builders with competitively priced options, but provides additional selling points of low life cycle costs, energy efficiency, superior fire resistance, acoustic efficiency, and natural resource conservation. *Hebel* is the world leader in manufacturing and distribution of AAC products and produces more than 31 million cubic yards annually (Hebel, 1998). The 400,000 cubic yard annual production rate of its recently opened manufacturing facility in Adel, Georgia is just a beginning in the evolution of residential construction in the United States.

AAC industry intent is to integrate its material into the full spectrum of U.S. design and construction applications, making it a conventional system alongside steel, concrete, and wood. The use of AAC structural systems in U.S. commercial applications is already gaining momentum, with increasing sales every year. The nature of precast systems is somewhat better adapted to commercial structures due to the general use of repetitive bay designs. U.S. homeowners on the other hand demand uniqueness. The maximum cost benefit of AAC is attained through mass

production of products requiring no tooling changes on the production line. Although blocks for residential construction are efficient in production, there is some productivity loss on the construction site as blocks are custom fitted and shaped.

Precast autoclaved aerated concrete is the leading residential construction material in Europe and Japan. The leading material of choice in the United States is lumber. Unlike the rest of the world, lumber is prevalent in the U.S. and historically relatively inexpensive. Despite the emergence of several new residential framing technologies such as steel and a variety of portland cement applications, no innovative method has been able to penetrate the mainstream stronghold of lumber in the housing market. It is highly unlikely AAC technology will replace lumber in the residential market, but it is AAC's intention to compete head to head with lumber, and attain market share as an equal or better residential construction material.

AAC structural systems are already proven to work all over the world. They simply must be promoted and priced such that they are competitive in the U.S. market against lumber. With a specific program in place, the AAC industry will gradually change the way design and construction professionals view residential construction. With full knowledge of AAC applications, environmental benefits, technical capabilities, and unique requirements, consumers and builders will reap the benefits of this sustainable construction product while preserving environmental resources.

Still, the U.S. residential market presents a challenging goal to the AAC industry. Why are innovative construction methods necessary? What exactly is AAC? How can this proven system compete against current U.S. methods? This research answers these questions through identification and summary of appropriate technical and marketing issues. With programs in place to address these issues, the industry will guide AAC to its rightful place as a standard in U.S. residential construction.

Residential Construction Background

The dominant material in residential construction within the United States is wood. Construction industry statistics show 94% of new homes are constructed using exterior and interior wood framing (Dodge, 1990). In mid-1992, increasing concerns of environmental preservation and endangered species forced federal restrictions on logging (Lemonick, 1991), and in a dramatic turn of events, by mid-1993 lumber prices nearly doubled to a peak of around $500 per 1,000 board feet. Not only are the resultant price increases significant, but the sharp fluctuations created a volatile market for timber sales. The average weekly change in the framing lumber composite price varied in 1993 between $10 and $15 per 1,000 board feet, or about three times the rate of change experienced in the 1980's (HUD, 1994). Although lumber prices receded to a current value of about $430 per 1,000 board feet (Random Lengths, May 1997), the subsequent instability of the lumber market since 1993 has led to such drastic measures as stock market hedging in lumber futures (Lurz, 1994). Also, despite forestry management methods, some critics of the lumber industry state the long term outlook on quality lumber is poor due to harvesting high-quality forests at a rate greater than they are replenished.

Despite the growing cost, tremendous price fluctuations, and an unsure future, builders continue to use lumber. When investigating concrete as an alternative to lumber, builders can not seem to get a comparable house at a comparable price. After factoring in new labor skills, building code differences, increased costs from subcontractors unsure of their role, and making it all work to satisfy customers, any savings from less expensive materials is lost. It makes more sense for them to ride out the trouble, and continue using wood (VanderWerf, 1995).

In 1993, The U.S. Department of Housing and Urban Development (HUD), Office of Policy Development and Research published the first report of ongoing research studying alternative structural materials for residential construction. In the interest of consumers and the residential construction industry, the National Association of Home Builders (NAHB) was commissioned by HUD to conduct this study to review and identify viable innovative construction materials. Although a variety of sponsors participated in the study, including the Portland Cement Association with several concrete applications, AAC was not identified in any of these reports.

A preliminary literature review of state of the art residential construction technology reveals little about application of precast autoclaved aerated concrete in the U.S. There are, however, several international publications on the subject of AAC structural properties. Although the Portland Cement Association (PCA) has recognized it and included it in its 1995 publication, *The Portland Cement Association's Guide to Concrete Homebuilding Systems*, little has been done to integrate it in the mainstream residential construction industry. The Portland Cement Association readily admits that very little documentation exists concerning AAC. The U.S. Department of Housing and Urban development has yet to recognize AAC in any of its publications on research of alternative residential construction materials.

In response to tremendous lumber price hikes, and in the interest of consumers and the residential construction industry, the U.S. Department of Housing and Urban Development (HUD), Office of Policy Development and Research, commissioned the National Association of Home Builders (NAHB) to review and identify viable alternative structural materials for housing construction. The initial result, *Alternatives to Lumber and Plywood in Home Construction*, published in 1993, identifies several innovative technologies. Further study results released in 1994 (*Alternative Framing Materials in Residential Construction: Three Case Studies*) provide insight into the installed cost of three systems; Foam-Core Panels, Light-Gauge Steel Framing, and Welded-Wire Sandwich Panels. Continuing its research into new materials, HUD released a 1995 report, *Innovative Structural Systems for Home Construction*, presenting Wood Structural Insulated Panels and Insulating Concrete Forms for conventional residential construction, and a detailed follow-up report, *Insulating Concrete Forms for Residential Construction: Demonstration Homes*, published in 1997. Despite *Hebel's* presence in the U.S. since 1990, AAC was not identified in any of these reports.

In an effort to continue HUD's research into new materials, this research presents precast autoclaved aerated concrete as an alternative technology for conventional residential construction. HUD's research addresses the technical aspects of alternative construction materials, but does not

address the more difficult aspect of acceptance and adoption of that technology. This research identifies the needs of home buyers / owners, and their willingness to purchase the technology to support those needs. These technical and marketing positions will be used ultimately to develop a marketing plan to modify product form and stimulate adoption and sustained use of AAC.

AAC industry's initial intent was to promote AAC technology in both commercial and residential markets. Applications are rapidly growing in the commercial construction market. Steady growth is attributed to architects and engineers becoming more familiar with AAC. But at a slightly higher cost than lumber, AAC is considered a "premium" product for residential applications, and as such has been limited to custom homes. With revenue from and proven performance in the stronger, more immediately profitable commercial market, AAC companies are better prepared to take on the lumber dominate housing industry.

AAC Product Overview

AAC is a lightweight, structural, precast building material of uniform cellular structure. It is formed by combining sand, lime, cement, gypsum, water, and an expanding agent, which forms a porous, microstructure in the concrete. At one-fifth the weight of concrete, the solid units are easily placed and secured with a thin-bed mortar. With wood-like behavior, blocks shape easily and fasten using common woodworking tools and fasteners. The masonry-like units and reinforced panels are a part of a complete range of products that enable a structure to be built entirely of AAC (Hebel, 1998). The entire structural shell including, basements, walls, stairs, floors, and roofs are all made from precast autoclaved aerated concrete products. AAC was used to build a seven story hotel in Atlanta in preparation for the 1996 Olympic Games.

History of Autoclaved Aerated Concrete

Although new to the United States, precast autoclaved aerated concrete is a proven construction material used successfully in Europe for over 70 years. As an alternative to lumber, AAC provides additional selling points of low life cycle costs, energy efficiency, superior fire resistance, acoustic efficiency, and natural resource conservation. The world leading manufacturer and distributor of AAC products is Germany's *Hebel*. *Hebel* established its first U.S. operation in Atlanta, Georgia to introduce AAC to the U.S. in 1990. Another European (Swedish) company, *Ytong*, soon followed and set up operations in Haines City, Florida (Near Orlando).

Materials Used in Manufacture

AAC is manufactured from sand, cement, lime, gypsum, water, and an expanding agent. Unlike lumber, all of these materials are readily available and are abundant natural resources. Since the finished product is nearly five times the volume of the raw materials used in manufacturing, this product uses resources very efficiently. The mixture is poured into a large mold and steam-baked in an autoclave. Following the autoclave process, the large block is cut into precise blocks. Reinforced products follow the same process, but reinforcement is also placed in the mold. The block is shaped to interlock with mating pieces following the autoclave process.

Energy Conservation Benefits

AAC is an easy to use environmentally friendly construction material. Only a fraction of the energy used in production of other building materials is used in the production of AAC. Additionally, no pollutants or toxic by-products are produced during the manufacturing process. AAC is also completely recyclable (Hebel, 1998).

The R-value of 8 inch AAC walls is better than that of a wood stud wall with R-30 insulation (Hebel, 1998). The combination of R-value, thermal mass, and air tightness work together to establish energy efficiency that far surpasses any comparable wood stud wall. Figure 1 shows a sample wall section that had an exterior temperature fluctuation of approximately 126°F, while the interior wall temperature maintained 68°F with only 2°F variation.

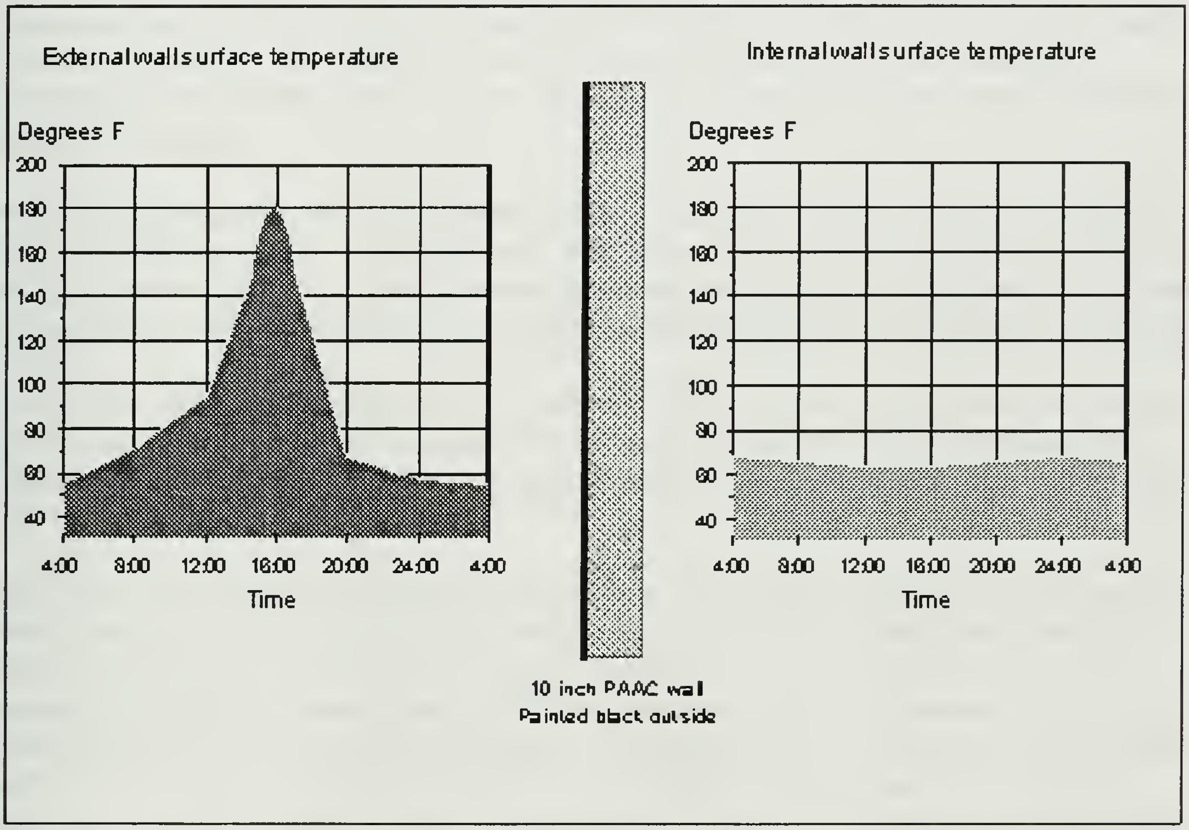

Figure 1. Thermal efficiency of a AAC wall system

Source: Fraunhofer Institute for Architectural Physics - Germany

In addition to greatly moderating the interior temperature, there is a lag time of about eight hours from the exterior peak temperature to the interior peak temperature (Hebel, 1998). This lag time allows energy consumption to be shifted to off-peak hours. This is a cost benefit to homeowners and a load management benefit to power companies.

Airtightness is another characteristic of AAC construction that saves costs and energy. Research (Yuill, et.al., 1997) shows that reduced air exchange due to leakage not necessary for ventilation saves energy costs. This was proven for both warm and cold climates. Reduced air exchange due to leakage also offers the opportunity to use a smaller HVAC unit, and for subsequent lower initial costs for the builder and buyer. The research highly recommends building "substantially airtight" structures, and relying solely on the mechanical system for ventilation.

Environmental Benefits

As an integrated structural and insulation system, no other single construction material can match its design flexibility, rapid construction, energy efficiency, and low life cycle costs. Design flexibility and rapid construction allow builders to construct a quality structure in a short time, and move on to the next project. The energy efficiency translates to lower utility costs for homeowners, and lower initial costs for smaller HVAC units. Also by using less energy, natural resource are conserved. Low life cycle cost is the result of lower utility cost, little to no maintenance of the structure, and an overall "healthy" home through high resistance to air flow through the structure.

AAC is an inorganic solid wall that is insect resistant. It is not possible for insects to inhabit or breed in them as is possible in other systems. Without concern of termites and other insects damaging or inhabiting the structure, chemical treatments are reduced or eliminated. Associated environmental and health threats are avoided by not putting chemicals in the ground or in the air.

A commonly overlooked environmental problem in residential construction is that of noise. The solid wall construction of a building made of AAC provides excellent sound abatement. This greatly reduces the effect of outside environmental noise, providing a quieter more comfortable interior for residents.

Durability is an important factor when considering use of a building material. A structure that does not need major repairs or renovation every twenty years or so, as many wood products require, can save money, inconvenience, energy, and other resources. This is of tremendous advantage to the building owner, creating a better investment. AAC has proven to be a very durable material. There are numerous structures worldwide, many over 50 years old, in excellent condition. AAC will not rot, warp, rust, corrode, or otherwise decompose. The very low maintenance of a AAC building saves considerable maintenance time and money over the life of the building (Hebel, 1998).

As a construction system, AAC provides significant environmental and other benefits for the builder and the home owner. The short and long term benefits of AAC are lower energy consumption, reduced insurance and operating costs, greater safety and comfort, and a healthier, trouble-free house. These features provide a better investment for the home owner, and for the environment.

From an engineering perspective, AAC is an ideal residential construction material for a sustainable environment. It is easy to use on the construction site due its light weight and is placed using typical mason skills. Its unique characteristics allow it to be cut and shaped like wood and typical fasteners (i.e. nails, anchors) can be used to attach furring strips, picture frames, curtain rods, etc. The combination of thermal mass, air tightness, and inherent insulation create an energy efficient structure that saves resources and homeowner costs. Fire resistance of AAC far exceeds the capabilities of lumber homes, containing the fire, saving the structure and household affects, ultimately reducing insurance premiums. AAC structures have a higher resistance to high winds and hurricanes, and are impervious to insect attack (such as from termites). AAC is also much more effective in reducing noise transmission. All these benefits are achieved with much less maintenance as wood structures. A complete cost benefit comparison is in Appendix A. All of these benefits are clearly desired by every homeowner, so why would homeowners not want AAC in their home?

The primary reason AAC is not a common building material is cost. Presently, AAC is marketed as a premium product costing 5% to 7% more than the entire cost of a house just to construct the exterior framing system and upper level ceiling using AAC. As such, its use in residential construction has been limited to custom home applications. Consumers aware of AAC's capabilities that can afford a custom home are able to specify AAC for construction. For the average home buyer this is not an option. The average home buyer relies on the builder's selection of materials. The competitive nature of residential construction leads builders to use the least expensive material available. If life cycle costs of an AAC home are lower than a lumber home, the AAC home is less expensive over the expected use period of the home. For an average home buyer looking at a new mortgage, it is difficult to perceive how a higher fixed monthly payment for a "premium product" is less expensive over the life (or use) of the home. Unfortunately, builders simply will not take the risk and build homes using the more costly AAC without a guaranteed buyer. The subsequent "up front" cost of the homes will send uninformed buyers to the neighboring builders' development.

In present form, AAC products are not a true replacement for lumber construction. The 5% to 7% cost premium is only to build the exterior walls and upper level ceiling using AAC. The interior walls, second story floors (if applicable), and roof are still constructed using traditional materials (wood or light gage steel). This is again a cost issue. The primary cost benefits of AAC are attained in the exterior wall and ceiling system. Building interior walls and floors with AAC will increase costs, but not provide significant additional savings. The cost of using AAC for a roof is costly due to the many angles, dormers, and penetrations. To ensure the energy efficient integrity of an AAC system, the upper level ceiling is constructed using AAC. Homes in Europe are made entirely of AAC due to the lack, and subsequent cost premium, of lumber. Another significant factor in European applications is the stringent building codes requiring high energy efficiency. The high cost of European utilities also encourages home buyers to seek homes with high energy efficiency and low life cycle costs.

Another reason AAC is not a true replacement for lumber construction is the lack of cavity between wall panels and in the floor or ceiling panels. Traditional construction methods rely on the cavity between wall panels to run electric and plumbing utilities as well as cable, intercom, and alarm systems. If the builder chooses to finish the interior with furring strips and drywall, the ¾" space is used for most utilities. Otherwise, channels are routed into AAC to run utilities. Following utility placement, the channel is filled with plaster, or just covered with drywall. The lack of "normal" cavities is an important issue easily resolved if planned (or designed) in advance.

The general consensus is that consumers want the benefits provided by AAC, and are willing to pay extra for improved disaster resistance, pest resistance, energy efficiency. An interactive internet survey was established to determine exactly how much buyers are willing to pay for AAC and at what rate of payback is acceptable.

Research Methodology

Developing residential construction products and a marketing plan requires knowledge of consumer needs and perceptions related to the housing market. This information is even more important to overcome the difficulty of acceptance and adoption of this technology. The primary research mechanism through which this report is developed is through an interactive internet-based customer survey. The results of this survey are compared to the three year old *Homeowner Report* by the Portland Cement Association (Portland Cement Association, 1995) developed to determine attitudes and perceptions concerning the use of concrete in new single-family homes. A secondary mechanism of this research is interviews of professionals within the residential research and construction industry.

Survey

Initial intent of the survey was to conduct approximately 500 personal interviews each in the Atlanta and Dallas metropolitan areas. These metropolitan areas were selected primarily due to *Hebel* having corporate operations in these cities, but also due to their standing in the mainstream residential construction market, and their representation of major metropolitan standards. Starting in the Atlanta area, it was soon discovered that malls, home centers, builder showcases, and other assorted businesses would not allow customer interviews for one or both of two reasons: (1) policies in affect that prohibit soliciting their customers, or (2) existing contracts with survey companies assuring sole access to customers.

Proprietary survey companies charge $20 per contact incident (Quicktest, 1998). With no financial backing, and the advent of electronic media, the next obvious avenue was an interactive internet-based survey. Additional responses were gathered through distribution of a hard copy paper survey based on the electronic survey version.

In addressing the advantages and disadvantages, the internet survey actually benefits in many aspects that traditional surveys have problems. Anonymity in the internet version allows the

consumer to be totally honest. Since the internet survey must stand on its own with the customer, there is no interviewer bias that can plague personal or telephone interviews (Rea, 1992). The premium benefit is cost. Access to most electronic email lists are free, and internet sites are free, depending on the location of the server. The only disadvantage is the survey precludes anybody who does not have access to a computer and the internet.

Development of Survey

In order to eliminate bias in the survey results, the questions are worded in a way that do not invoke a particular response (Fowler, 1993). All question are general in nature and do not mention AAC or any other building material (See the actual survey in Appendix B). Although the initial intent was to minimize the survey to 5 questions, further efforts to clarify questions and separate issues resulted in expansion to 9 questions. Minimizing the survey length is a key initiative to encourage consumers to participate, and to keep them interested long enough to complete the survey.

The actual focus of the survey is to answer three questions:

1. What characteristics of a house are important to the consumer.
2. How much are consumers willing to pay for improved characteristics.
3. At what rate of payback for premium benefits are acceptable.

The characteristics are focused on the superior benefits provided through use of AAC products. The consumer is asked to rank 6 characteristics (Appearance, Maintenance Cost, Disaster Resistance, Durability, Energy Efficiency, and Initial Cost) in the order of most importance. The characteristics are listed randomly to preclude order bias by the researcher's preferences. Intended region of purchase is of particular interest since their concern for certain characteristics may be attributed to the conditions of each locality. Additionally, the house cost and size are reported to compare characteristic ranking and spending patterns. The number home purchase is asked to indicate how long they intend to stay in the house. Those that intend to stay in a house for longer periods are expected to be more concerned with life cycle costs versus immediate costs.

Questions #6 through #8 ask how much more the consumer is willing to pay for premium benefits. The Portland Cement Association's survey asks a similarly formatted question, but uses responses in the form of percentages. It is felt that even educated consumers may perceive 4% or 5% to be a low cost for a premium benefit without actually calculating the cost. It is easy for a customer to state they would pay 4% for something, but when it comes down to the actual purchase, they may not be willing to obligate an additional $6,000 (for a $150,000 house). The survey intends to determine exactly what the customer will actually purchase.

Internet. The electronic version of the survey is posted on an internet web site, with the actual files stored on the *America Online* server (http://members.aol.com./gt7768). The web-based hypertext markup language (HTML) form sends the respondent's information to the researcher via e-mail. To get the form to send the information in a legible format, the information must first

be processed in a CGI program. To maintain a legitimate research appearance it was intended to place the survey on the Georgia Tech server. Limited access to that server and the ability of it to properly process the form responses prompted the survey to be placed on the *America Online* server under a screen name established solely for this research.

Hard Copy. Seventy-five hard copy surveys were produced by printing the internet survey. Despite being distributed solely in the Atlanta metropolitan area, they did not necessarily produce responses for the South Atlantic area. Several respondents intend to purchase homes outside the South Atlantic region. Hard copy surveys were distributed to military and civilian employees at *Naval Air Station Atlanta,* and the Marietta business office of *Leaseplan, U.S.A.*

Distribution of Internet Survey

The survey sampling is developed around the simple random method. This would be the method chosen for a traditional mail or telephone survey based on the expected population intended for data collection. The expected intercept population is anybody in the market to purchase a new home. The market research analysts at *Elrick & Lavidge*, in Atlanta, provided insight to the principles of survey sampling to ensure the results would be accurate. To attain a confidence factor of 95% and an accuracy of ±5% using traditional survey methods, the survey would have to be sent to 741 recipients.

Despite the efforts of marketing companies to keep up with addresses and phone numbers, there is a chance the survey may not get delivered to the intended recipients. Additionally, once the recipients receive the survey, there is a less than 50% chance they will even respond. Even if they do respond, it may not be complete or accurate (incidence). The rates of working addresses (or phone numbers), cooperation, and incidence vary greatly depending on the database used and the type of target recipients. For this survey's intended targets, Bill Salokar of *Elrick & Lavidge* recommends the following rates:

Working Address / Number Rate:	90%
Cooperation Rate:	40%
Incident Rate:	75%

With a base of 741 recipients, these rates translate to 200 accurate responses with a confidence factor of 95% and a result accuracy of ±5%. Unfortunately, the use of e-mail forwarding, the internet, and advertising through search engines precludes knowledge of exactly how many contacts are made.

Assuming AAC industry companies may make business decisions based on this research, *Hebel's* Vice President of Marketing (U.S. Operations), Bill Sutton, requested a response base of 1,000 customers. With a goal of 1,000 accurate responses, an estimated 3,100 consumers were reached through various methods.

The most difficult aspect of web-based sampling is getting visitors to the web site. Several methods were employed to invite participants to do the survey, but the advent of "junk e-mail" results in a relatively low response rates from direct e-mail invitations. Despite the web site being listed on the top 20 web search engines, there is low confidence that any significant volume of survey participants visited via this route. Table 1 summarizes the contact methods and estimated consumer contacts. The most effective contact response rates came from "lists." Lists are e-mail lists of people with particular interests. A moderator screens potential messages for interest applicability, then distributes the message to all the subscribers. Anybody can subscribe to a list for free. Due to the particular interests of subscribers, they are more likely to respond to the invitation to participate in the survey. Rapid response within the two days following posting on a list was indicative of the lists' effectiveness.

Table 1.

Summary of Estimated Survey Contacts

Direct e-mail addresses	524
Miscellaneous e-mail forwarding	100
Hard Copy forms	75
Mail Lists	
United States Military Academy	700
Roller Compacted Concrete Constr.	47
World Construction Set	154
Home Improvement	900
Environmental Forum	600
Total Estimated Contacts	3100

One other web link was established from the homepage of *Southface Energy Institute*, an Atlanta-based organization dedicated to residential energy, environmental, and sustainability issues. A courtesy link was added to the survey page to invite survey participants to view *Southface's* efforts.

The entire concept of internet surveys is fledgling, and there are no readily available resources to consult on methodology and sampling. During survey development only one resource was encountered with internet survey experience. *Decisive Technology* develops form survey software and performs survey services on the internet. The encounter occurred late in this survey process, and their use as a resource was minimal. See Appendix D for contact information.

Interviews

The interview phase of this research reveals the status and perception of AAC by major market home builders that specialize in specification homes (homes built prior to owner purchase) and by researchers at the National Association of Home Builders. Although *Hebel's* competitors were not interviewed, a brief summary of their activities are presented to provide an understanding of the state of the AAC industry, and the importance of prompt action to secure relationships with major market builders.

Major Market Builders

Initial interviews were conducted with personnel from three builders (*Centex*, *Ryland*, and *Pulte*) in the Atlanta area that construct specification homes nationwide. The summary of these

interviews reflect only the status and perception of AAC in the Atlanta regional offices. The summary results of these interviews are quite interesting. Calls were placed to different offices within each company to make interview appointments. Marketing and purchasing managers, as well as architects and engineers were contacted. In the competitive nature of nearly every business, one would expect national home builders to be actively searching for innovative materials and construction technologies to enhance their market share. In every case, not one person was interested in setting up an appointment to discuss this research. In fact, several other builders contacted were not even interested enough to discuss it on the telephone.

Those builder representatives willing to discuss this research on the telephone generally are categorized in one of the following three categories:

1. Never heard of Autoclaved Aerated Concrete (or by any other name).
2. Heard of it, but no knowledge of benefits, applications, cost, or installation skills.
3. Aware of it, but not willing to do anything different for fear of losing market share.

The most surprising aspect of these interviews is that they were not even interested in the research findings. Many people contacted in the course of events of this research have requested a copy of the final results. These representatives have not. Gaining no cost support to the research effort such as access to their customers or exit poll summaries was just as fruitless. Suprisingly, the *Centex* office in Dallas is working with the *Hebel SouthCentral* operation to develop a cost effective AAC specification home for that area. The similar climatic Atlanta *Centex* office is not aware of this relationship or the impact it could have for future construction.

National Association of Home Builders Research Center

A wealth of information was revealed through a telephone interview with Ed Hudson of the *National Association of Home Builders (NAHB) Research Center*. The Research Center has extensive experience with innovative building products and conducts a variety of structural testing as well as time and motion studies. Ed Hudson directed a study in 1996 that addressed time and motion issues associated with AAC construction. The general summary of this study revealed that AAC is indeed a superior product for residential construction, but some marketing and technical adjustments are necessary to make it competitive with lumber systems.

Cost is the primary issue. Builders are not searching for products that cost more. Of course they want build a product that will last longer, and be more energy efficient, but not at the expense of losing market share. What is needed is a compromise that will lower costs, and enable AAC to be marketed, not as a "premium upgrade," but as a superior framing system costing the same, or less, as lumber framing. The philosophy that AAC should cost more since it is a premium product is a poor marketing position. The NAHB research team feels the AAC industry may have originally underestimated the role of this cost premium. Although the quality of benefits provided may justify the premium cost, it can only be marketed in the mainstream specification home market if the customers are thoroughly educated. As a side comment, it is important to note there is no

environmental or health research to determine the benefits or impact of using AAC as a construction material.

To reduce costs, the NAHB recommends modifying the AAC system in ways that improve installation productivity. The reduction of productivity costs (and thus labor costs) has the greatest impact on cost of any construction project. The time and motion study recommends developing improved methods for connecting interior walls. At the time of the study, hollowed AAC "lintel block" was filled with reinforcement and mortar. Another recommendation is to use another product (such as steel) for lintels. The disadvantage of using steel is the labor necessary to conform it to the block structure, and its high heat transfer characteristics place a thermal "hole" in the structure. The AAC industry responded by producing complete lintel units precast with reinforcement. This product saves considerable construction time while maintaining the AAC integrity (and benefits) of the structure.

A current selling point of AAC is its claim that thermal performance of an eight inch thick wall performs better than a conventional stud wall with R-30 insulation. This claim is based on an energy consumption analysis conducted in Georgia and Central Florida (Sterling, 1993). The R-30 comparison is actually somewhat deceiving. An eight inch thick AAC block actually has an R-value of 9.0. However, the combination of this R-value, high airtightness, low thermal conductivity, and high thermal mass give the structure thermal performance equal to that of an R-30 insulated stud wall. The current primary markets of Georgia, Texas, and Arizona have climates similar to central Florida, but as the market spreads to the northern regions of the U.S. this energy consumption comparison should be reevaluated due to differences in heating and cooling cycles. The difference in northern climates will not necessarily have the same effect on all these factors, and the R-30 rating may not be appropriate in the northern regions of the U.S. Although AAC will still provide superior thermal performance over traditional stud framing, the current energy codes impart a somewhat detrimental effect on the R-value rating claim since there is nothing in the codes to credit AAC for benefits other than R-value (Hudson, 1998).

Competition

Competition on the horizon means quick action is imperative. When *Hebel* started its U.S. operations in 1990, they were the only company in the U.S. promoting AAC. In just the past 5 years, several competitors have appeared, including Sweden's *Ytong*. Some of the other new U.S. corporate faces are backed by names familiar to the European AAC marketplace.

The second largest producer of AAC products in the U.S. is *Ytong*. U.S. operations were established in 1997 in central Florida. As with *Hebel*, primary focus is on production and commercial sales, but are also using AAC in custom home applications. *Ytong* also has a strong presence in the European AAC market, but not near the level *Hebel* has attained. Due to their worldwide experience, *Ytong* is a serious competitor.

Babb Cellular Concrete LLC, of Ringgold, Georgia has just started construction of a pilot plant to manufacture AAC from fly ash (Engineering News Record, 1998). They also are negotiating to

build additional plants at several of the Tennessee Valley Authority's fossil fuel plants. This production venture is beneficial to the chronic problem of ash disposal. However, this research did not reveal sales or application concepts for their product. Other power companies in Pennsylvania and some midwest states are also working to develop contracts with manufacturers that will use fly ash in the production of AAC.

A company in Arizona, *Truestone America*, is building homes with their version of AAC. This division of a Swedish company, *Svanhome*, may have a significant proximity advantage in the race to capture the West Coast market.

Survey Analysis

The purpose of this survey analysis is to determine the validity of consumers' willingness to pay for premium construction products and associated benefits. Research survey results are presented and compared to appropriate similar data in two other surveys conducted in 1995. The comparison is made to validate results, and determine if trends have changed over the 3 year period between survey samplings.

Professional Builder magazine funded a 1995 survey to find out how much home buyers are willing to pay up front in premiums for energy efficiency and maintenance (or life-cycle) costs. The survey includes responses from more than 700 consumers that recently purchased a home, or intend to buy a newly built home (McLeister, 1995). The *Portland Cement Association* conducted a homeowner survey in 1995 to determine the attitudes and perceptions concerning the use of concrete products in single family homes. The homeowner survey was mailed to 1,600 households that had previously agreed to complete questionnaires. 970 consumers responded. The Portland Cement Association is in the process of compiling homeowner data from a 1998 survey that is expected to be released in August 1998.

Statistical Validation

Approximately 3,100 consumers were contacted through e-mail and invited to visit the internet web site to answer the 9 question survey. Upon completion of the survey, the form automatically sends the results to the researcher via e-mail. 761 responses were received. 131 responses were incomplete or not completed correctly, and subsequently disregarded. The remaining 630 are considered valid. Of the 3,100 requests, 75 were actually hard copy survey. Of those, 63 were returned. This small volume is relatively insignificant in the scope of the entire response base. A total of 693 valid responses are included in the survey data.

The use of internet based survey sampling is so new, statistical standards have not yet been established. With guidance from the marketing research company of *Elrick & Lavidge*, Atlanta, Georgia, and the statistical validation of the *Portland Cement Association's 1995 Homeowners Report*, this survey is validated at the 95% confidence level with a margin of error of plus or minus 5%. Although the 22% response rate of this survey is significantly lower than the 60% rate

of the PCA survey, it is only slightly lower than typical mailed survey responses, and actually quite strong considering the use of e-mail. E-mail messages are readily discarded. The *Homeowners Report* had 970 responses from a known sampling base that had previously agreed to answer questionnaires on a variety of subjects.

The strong response volume of 693 is what keeps the margin of error to less than 10%. Market research specialists recommended at least 200 responses to validate the survey at the 95% confidence level with a margin of error of plus or minus 10%. The large response base keeps the margin of error low (less than 5%), but the use of electronic access degrades the certainty of the sampling. Since there is a possibility some of the surveys were completed by people not within the parameters of a home buyer (age, for example), the margin of error is increased to approximately 5%.

Critical Analysis

Initial cost and appearance were reported as the most important features to the majority of customers. However, appearance, durability, and energy efficiency are very closely ranked. Although home buyers in the low end and high end price market have slightly different interests and priorities, specific marketing programs may need to be prepared for these customers to capitalize on those trends. Buyers in the low and moderate price markets report initial cost as the most important characteristic, while customers in the high end price market report appearance as the most important characteristic.

Energy savings, maintenance costs, and disaster resistance are all very important issues to home buyers. Several comments reported hesitancy to rank them. Regardless, over 90% of buyers reported they would pay more for a home that incorporated even one of these features. Over 85% of buyers would spend more than $1,500 each for energy savings and disaster resistance features.

Desired Home Value

Forty-eight percent of the customers reported their next home purchase would cost $125,000-$199,000. Only 3% and 4% respectively intended to purchase homes costing <$75,000 and $350,000 or greater. Homes costing $75,000-$124,000 and $200,000-$349,000 are the next purchase of almost one-quarter of the customers for each range (See Figure 2).

In contrast, Figure 3 shows the market value of homes the 1995 survey respondents live in. Twenty-six percent of those respondents live in homes valued less than $75,000. Another 36% live in homes valued between $75,000 and $125,000. By looking at the chart similarities in Figures 2 and 3, it is clear most respondents of this research survey intend to make their next purchase in the next higher cost category.

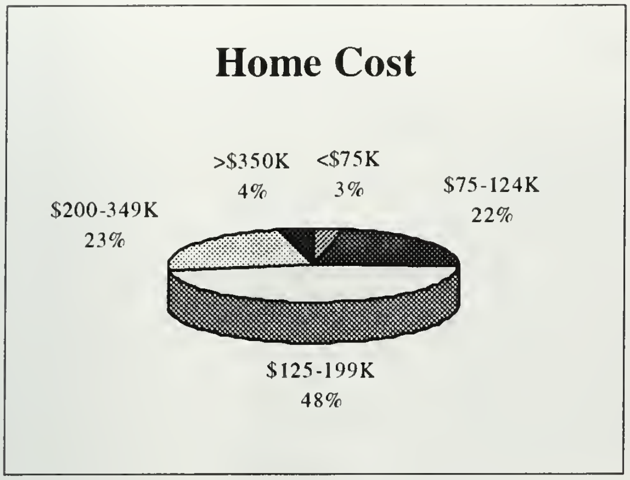

Figure 2. Cost of next home purchase.

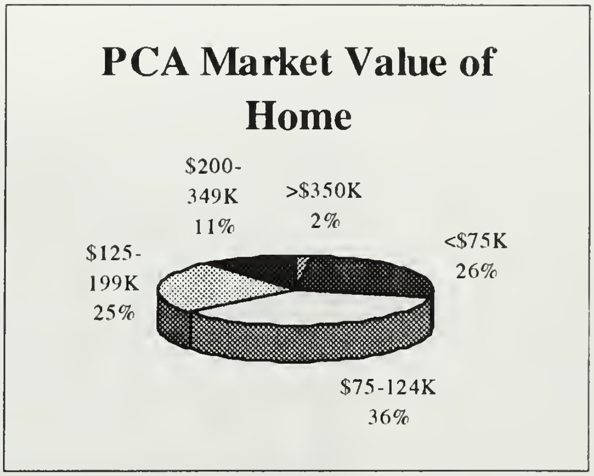

Figure 3. Market value of current homes.

Source: 1995 PCA Homeowner Report

Characteristic Rankings

Customers were asked to rank six characteristics when purchasing a new house. Figure 4 is a summary of these rankings using a weighted scale. Initial cost is ranked the highest, followed by a close grouping of appearance, durability, and energy efficiency. Maintenance cost is ranked fifth, and disaster resistance is ranked a distant sixth. Benefits ranked in the last 3 rankings are still important enough for consumers to spend extra.

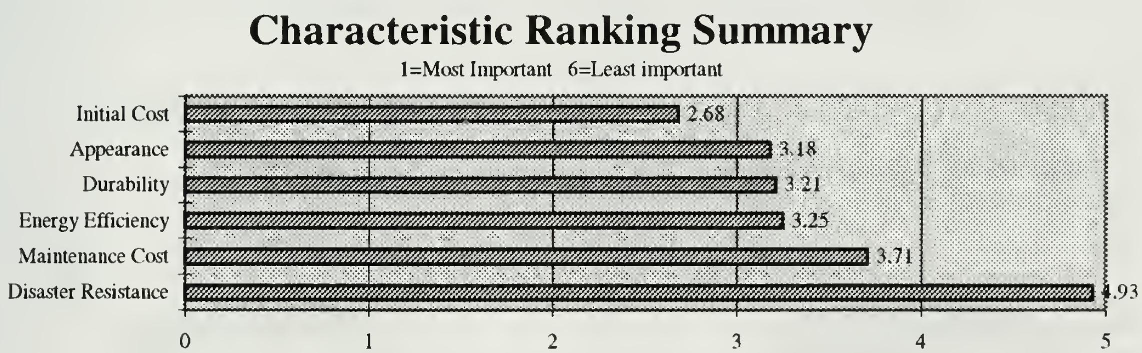

Figure 4. Rankings showing importance of house characteristics to consumer.

Table 2 is a matrix of weighted rankings by region. In all regions except East North Central and Northeast, initial cost is ranked first. East North Central and Northeast regions ranked energy efficiency first.

Appendix C has additional weighted characteristic matrices by home cost and number of home. Characteristic rankings compared to home cost are scattered, but generally initial cost is ranked first in purchases less than $200,000. Appearance is ranked first in purchases over $200,000. Disaster resistance remains a consistent sixth place ranking, regardless of purchase price.

Table 2.

Weighted characteristic rankings by region.

Rankings by Region									
	P	MTN	WNC	WSC	ENC	ESC	NE	MA	SA
Appearance	3.26	2.59	3.66	2.99	3.95	3.51	3.54	2.72	2.96
Maintenance Cost	3.9	3.73	3.97	4.04	3.79	4	3.56	3.24	3.56
Disaster Resistance	5.08	5.22	5.2	4.68	5.05	4.74	4.62	5.05	4.99
Durability	3.38	3.19	3.11	3.28	3.1	3.36	3.15	3.35	3.09
Energy Efficiency	3.14	3.68	2.8	3.29	2.28	2.76	2.88	4.13	3.55
Initial Cost	2.24	2.59	2.14	2.72	2.85	2.64	3.12	2.36	2.86

Rankings compared to the number of home purchase shows initial cost as the most important and disaster resistance least important in all cases.

Resistance to Natural Disaster

Eighty-two percent of the customers reported they would spend at least $1,500 more for a house that had greater resistance to the effects of natural disasters such as fire and hurricanes. Larger, more costly homes, accounted for the 8% reporting they would spend more than $6,000 for this benefit. These percentages are consistent with findings in the 1995 PCA survey. Figures 5 and 6 show the distribution of willingness to pay extra for improved disaster resistance.

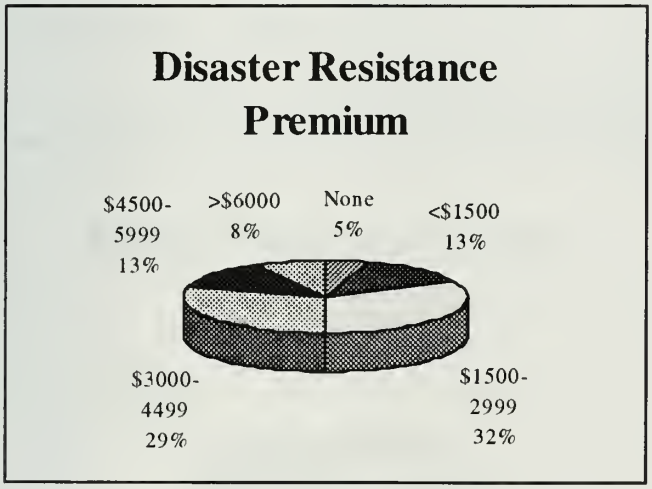

Figure 5. 1998 willingness to pay for improved disaster resistance.

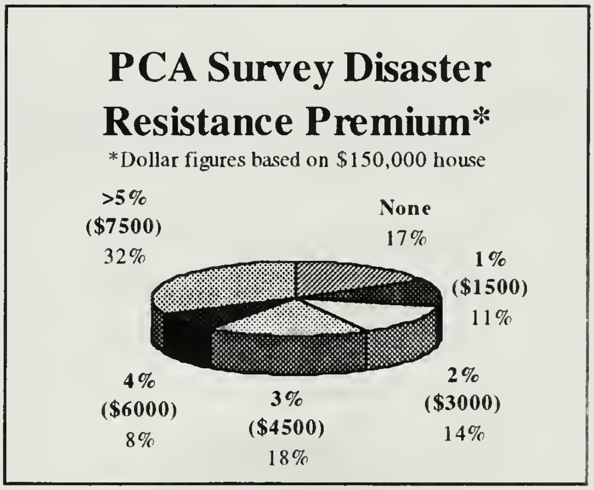

Figure 6. 1995 willingness to pay for improved disaster resistance.
Adapted from PCA Homeowner Report

The 1995 PCA survey showed a high percentage of respondents willing to pay more than $6,000 and a high percentage not willing to pay anything. The current research survey shows considerably lower percentages in both these categories, with the majority (61.4%) of consumers willing to pay between $1,500 and $4,500 for this benefit.

Additional data in Appendix C compares disaster resistance spending to the number and cost of the next home purchase, as well as regions. For purchases between $75,000 and $350,000, spending is consistent with the overall percentage (61.4%) of those willing to spend between $1,500 and $4,500. For purchases under $75,000 the percentage drops to 47.8% due to a significant percentage of customers (30%) not willing to spend any extra for this benefit. For purchases over $350,000 the percentage drops to 39.3%, but is countered by 42.8% willing to spend more than $4,500. Of that 42.8%, 35.7% is willing to spend more than $6,000.

Comparing the number of home to disaster resistance spending shows more customers are willing to spend $1,500 to $4,500 in progressive ownership. In this spending range, 57.4% first home buyers are willing. This percentage rises consistently to 63.9%, 65%, and 70.4% in second, third, and fourth home purchases. The percentage drops to 32% for fifth home buyers, but a significant number of buyers (30%) are willing to spend more than $6,000.

Although the PCA survey revealed a higher interest in disaster resistance spending in certain regions, this research survey did not show any such trends. All regions showed the majority of consumers (53%-73%) are willing to spend $1,500-$4,500 except the Middle Atlantic region which only had 37% interest in this spending range. The Middle Atlantic had 28.2% willing to spend at least something for this benefit, but less than $1,500.

The "Ranking vs. Spending Comparisons" in Appendix C shows only a slight trend in spending patterns regarding the rankings assigned to disaster resistance. Above $1,500 the participation varies from 94.6% in the top ranking to 76.9% in the lowest ranking. Regardless of how disaster resistance is ranked, it is still important enough for 82.5% to spend more than $1,500.

Improved Energy Efficiency

The research survey asked customers how much more they would spend for a house that would save 15-20% on energy costs. Ninety-two percent reported they would spend more for a house

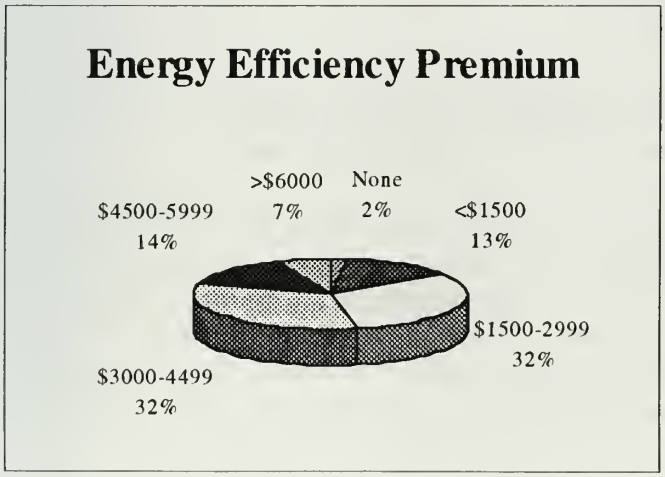

Figure 7. 1998 willingness to pay for improved energy efficiency.

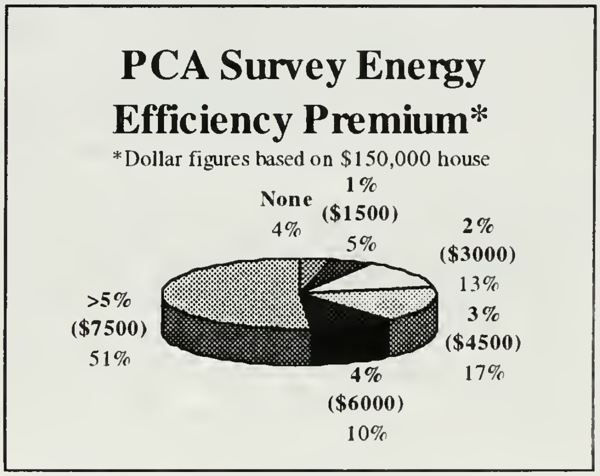

Figure 8. 1995 willingness to pay for improved energy efficiency.
Adapted from PCA Homeowner Report

that had greater energy efficiency. These percentages are consistent with findings in the 1995 PCA survey. Figures 7 and 8 show two separate survey results' distribution of willingness to pay extra for improved energy efficiency.

The 1998 survey showed only 7% willing to pay more than $6,000, but the 1995 PCA survey showed over 50% of respondents willing to pay more than $6,000. This high percentage could be attributed to the use of percentage-based instead of dollar figure-based questions. The majority of customers in the research survey (64.6%) would spend extra for this benefit in the range of $1,500 to $4,500. The *Professional Builder* survey found 81 percent of consumers willing to spend $2,000 up front to save $250 a year in heating and cooling expenses. Figure 9 shows that almost 20 percent of those consumers would spend an additional $1,000 to save the same $250 per year. Despite the differences in each survey approach, all three validate the fact that 80%-90% of all customers are willing to pay at least $2,000 to save approximately $250 (or about 20%) per year in heating and cooling costs.

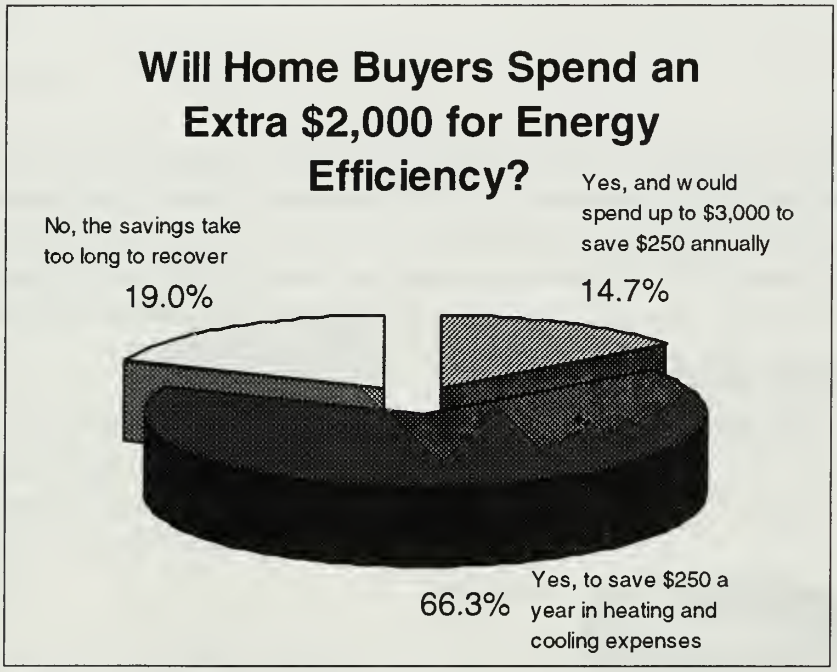

Figure 9. Buyers' willingness to pay for energy efficiency
Source: Professional Builder's 1995 Consumer Survey

Additional data in Appendix C compares energy efficiency spending to the number and cost of the next home purchase, as well as regions. For purchases between $75,000 and $350,000, spending is consistent with the overall percentage (61.6%) of those willing to spend between $1,500 and $4,500. For purchases under $75,000 no customer reported a willingness to spend >$4,500. For purchases over $350,000 the average spending range percentage drops to 39.2%. The reduction is attributed to two extreme positions. Fourteen percent of those purchasing a home costing over $350,000 are not willing to spend anything for improved energy efficiency. Another 21.4% are willing to spend only less than $1,500. On the other extreme, 25% of $350,000 customers reported a willingness to spend more than $6,000.

Comparing the number of home to energy efficiency spending shows this relationship has little to do with what the customer is willing to spend on this benefit. Across the board, customers are willing to spend $1,500 to $4,500 regardless of the number of home purchase. The only notable increase occurs in the fifth home when fewer customers report spending in the lower 2 ranges, and more report spending in the ranges >$4,500. Comparing energy efficiency spending to region reveals a slight increased interest in the East North Central and Northeast regions. This was also previously indicated in the weighted rankings. These two regions average about 80% of its customers willing to spend $1,500-$4,500 for this benefit, while the remaining regions reported 55%-65%.

The "Ranking vs. Spending Comparisons" in Appendix C shows a notable trend in spending patterns regarding the rankings assigned to energy efficiency. In the spending range above $1,500 the participation varies from 94.4% in the top ranking to 58.0% in the lowest ranking. Regardless of how energy efficiency is ranked, it is still important enough for 85.0% to spend more than $1,500.

Reduced Maintenance

The primary expense of maintenance in the context of this survey is framing material replacement due to pest infestation, and termite treatments. Water intrusion may also contribute to the need to replace certain framing materials. Figure 10 shows the distribution of customers' willingness to spend extra for features that offer superior resistance to termite and pest damage. Ninety-four percent of customers are willing to pay extra for these features.

Thirty-eight percent (38.4%) of customers are willing to spend in the range of $1,500-$2,999 for this benefit. Another 28.7% will spend up to $1,500 and 26.7% will spend more than $3,000.

According to the 1995 *Professional Builder* survey up to 72 percent of consumers would spend $4,000 to save $500 per year in maintenance costs (Figure 11). Almost one quarter of those willing to pay would spend $5,000 to save the same $500 per year in maintenance costs.

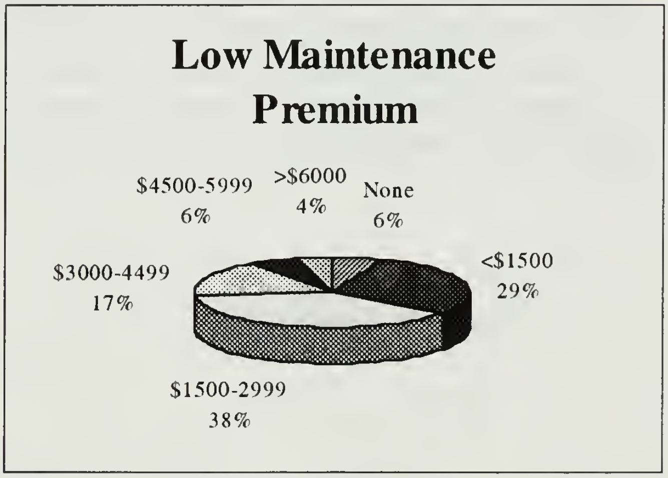

Figure 10. 1998 willingness to pay extra for features that reduce maintenance expenses.

Although the *Professional Builder* survey question is worded slightly different than the research survey, an approximate comparison between the two is possible. The 67.1% research customers willing to spend up to $3,000 is correlated to the 55.7% *Builder* respondents willing to spend $4,000. The differences in percentage are likely attributed to the $1,000 difference in spending limits. The *Builder* respondents showed 16.3% not willing to spend $4,000 for this benefit. This

high non-participation may be due to the "yes" or "no" format of the question and a single spending threshold of $4,000. The research survey showed only 6% unwilling to participate. At the upper spending limits, the research survey showed significantly more interest with 22.5% willing to spend up to $6,000, while only 16.3% of *Builder* respondents willing to spend up to $3,000.

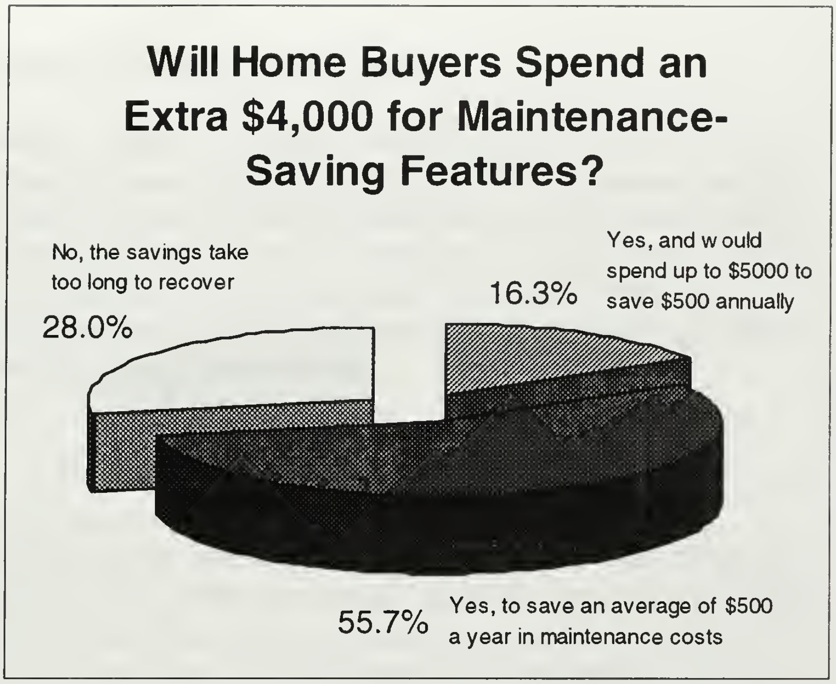

Figure 11. Buyers' willingness to pay for low maintenance.

Source: Professional Builder's 1995 Consumer Survey

Trends seen in Appendix C data show comparisons of maintenance-saving spending with cost of home, number home, and regions have spending patterns similar to other premium benefits, but the spending range is one category lower. In homes costing $75,000-$350,000, spending follows the average 67.1% in the $0-$3,000 range. In homes costing <$75,000, less consumers are in the average spending range, and tend to pay less. In homes costing >$350,000, less consumers are in the average spending range, and tend to pay more. The same pattern and spending range applies to number of home, with first home buyers paying less, and fifth home buyers paying more. Regional comparisons show a slightly higher interest in East South Central, Middle Atlantic, Pacific, and South Atlantic. These regions are more likely to have termite problems.

Payback Period

Sixty-five percent of customers expect a payback period of 3-9 years. Another 24% expect to break even in 10-12 years. Figure 12 shows the distribution of payback periods. Payback patterns based on cost of house reveal no particular trends. Consumers expect a 3-5 year payback in most price ranges except in homes costing <$75,000. More than 47.8% of consumers in this category expect a 6-9 year payback. Payback expectations continue to be 3-5 years for the first, second, and third homes, but rises to 6-9 years for the fourth and fifth houses. Regional comparisons produced scattered results.

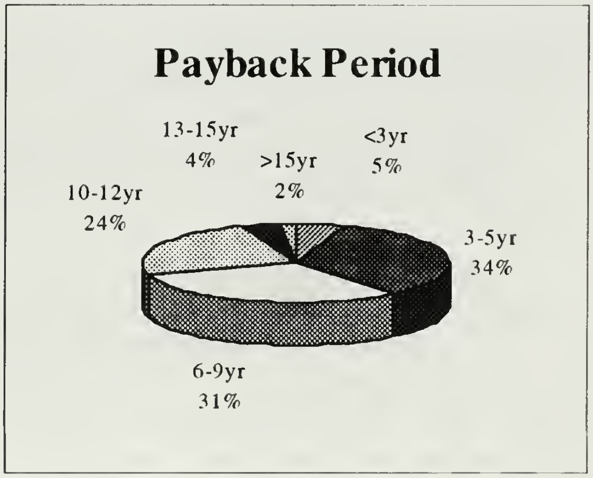

Figure 12. Expected break-even period for premium upgrade costs.

Alternative Product Development

Autoclaved aerated concrete is clearly a superior residential construction product in its current form. However, the competitive nature of home construction in the U.S., the economic position of lumber, and industry change hesitation demand a different marketing approach than is used in AAC construction elsewhere in the world. Every consumer and builder would like to have all the benefits AAC provides, but are not necessarily willing to pay more or change the way construction trades build homes. Two options to make AAC more appealing to U.S. residential construction are product modification and cost improvements.

Product Modification

Current residential AAC construction uses small blocks similar to concrete masonry units (CMU's). Block construction is generally labor intensive. Commercial AAC construction uses a combination of small block, jumbo block, and reinforced panels. The benefit of using small block is the handling ease. As with CMU and lumber, no lifting equipment is necessary on site other than for delivery. Using jumbo block or large panels would require lifting equipment on site. However, the benefit of jumbo block and panels is the reduced labor time by reduces the number of joints. A combination products can offset the product and equipment costs through labor savings. A product developed specifically to compete with traditional U.S. residential construction methods would be ideal.

The concept of product modification is already in motion at *Hebel*. They have already changed the lintel method by producing a precast unit. Also, they are developing a thin AAC panel that will attach to a light gage steel stud frame. This approach also addresses the wall cavity of which the U.S. construction industry has become so familiar and dependent. Wood and steel framed walls have a cavity that provide a means for simple utility installation. Even CMU's have voids that allow utilities to pass relatively easily. In solid block AAC construction, every utility route must follow the labor intensive process of being hand cut or routed.

A product concept developed by the author of this research is to produce full and half height AAC panels (with and without window and door openings) with pre-installed conduit for electrical and other wiring. The various panels could be assembled in a variety of combinations to construct unlimited house design combinations. Only very unique design features would need on site custom block placement. This concept is already used in other types of premanufactured framing systems.

Another way to modify the product is to couple it with an energy conservation program offered by utility companies, and local, state, and federal programs promoting energy efficient construction. Financial incentive programs are available to offset the costs of energy efficient innovative technology. Direct incentives are used to reduce the initial cost of these technologies, while rate incentives are used to encourage offset peak utility use (Vine, 1989). Regardless of the financial incentive used, it is a significant factor in further reducing the long term costs of an energy efficient AAC home.

Cost Improvement

The production processes are very important to the development of AAC as a new technology. The manufacturing process controls product cost. Retail costs can be minimized by designing and building structures within the efficiencies and constraints of the manufacturing process. It is also more efficient and less costly to produce as much of the finished product in a controlled factory setting. Developing standardized products for use in many different applications is cost effective and improves manufacturing efficiencies and quality control.

Although product modification may actually result in a more costly finished product, it must be designed such that it greatly reduces on site labor costs and produce a superior home. Unless the product costs significantly less than current materials, with equal or higher quality, it is not enough to convince builders to use. The overall cost of the home must be lower, the quality higher, and life cycle benefits better for builders to deal with the troubles of construction trade changes and coordination.

Conclusions

This research effort into the evolution of residential construction in the U.S. using Autoclaved Aerated Concrete summarizes the state of the AAC industry. AAC offers a premium construction product with added superior benefits of energy efficiency, disaster resistance, pest resistance, natural disaster resistance, noise attenuation, and low life cycle costs while reducing the environmental impact.

Through adaptation of current product design, application, and construction methods; including integrated design with other materials such as light gage steel, AAC will soon be cost competitive with traditional residential construction methods. The key to this transition is the unique relationship of AAC products' ability to meet the needs of consumers and builders. The supporting research survey shows the majority of consumers are initially willing to spend more for superior benefits, and subsequently for construction products featuring those benefits. Their willingness to pay extra is contingent on understanding the connection between building products and their benefits, how much they are paying for them, and the life cycle cost savings they will receive in return.

Current residential designs are generally engineered around the traditional building method of lumber framing. Applying AAC to those designs requires engineers to convert existing designs and oversee permitting and code approval. Needless to say, this is an inefficient way to design and build a house. Also of important notice is current residential AAC construction still relies on lumber or light gage steel for interior walls and roofing systems.

Beyond the scope of this research is future potential research and development of educational curriculums and computer design software. The educational need might extend even beyond

institutions of higher learning to a whole new consulting industry. Software development for AAC could mean new businesses or be new divisions in computer software firms already in business.

This research is a comprehensive tool as an introductory device to educate consumers and builders, and to provide consumer marketing data for the AAC industry. As an educational and informative tool, it will be instrumental in changing the way U.S. residential design professionals and homeowners view AAC construction systems, and make AAC systems as familiar as wood stud systems. Changing this view will encourage builders to adopt this emerging innovative building material and promote it in the residential construction market.

As AAC construction becomes more commonplace, it will be considered by builders and consumers as a conventional material and construction method. Moreover, this technology will provide consumers a long overdue option to lumber construction. Not only will consumers benefit from low utility and life cycle costs, but the environment will benefit from its energy efficiency and natural resource conservation.

Recommendations

The Autoclaved Aerated Concrete industry has many engineering and marketing decisions to shape their products into a viable alternative to traditional residential wood cavity construction. It is of the utmost importance that decisions are based on consumer and builder perceptions and opinions that reflect the buying public as a whole. The survey associated with this research provides the most up to date consumer preferences, and is in line with previous similar surveys conducted in 1995. It would be wise to also consult the *Portland Cement Association's 1998 Homeowner Report*, which is expected to be published about the same time as this report.

Continue modifying existing products to better accommodate the needs of the U.S. residential construction industry. Modifications should consider modular manufacturing in a controlled setting to improve manufacturing productivity, cost, and quality control, while reducing on site installation labor costs. Improved products and installation methods can be applied in other world settings to increase AAC use and further profit in those markets.

Hebel's strategic alliance with *Centex Homes* is exemplary in developing products, construction methods, and consumer education programs that will benefit both organizations as well as the residential construction industry as a whole. With several competitors on the horizon, it is essential to establish proprietary relationships with as many regional and national homebuilders while they are still available. Not only will this provide solid working relationships for future product orders, but the AAC industry benefits from the builder's extensive marketing experience and educational promotion capabilities.

Establish relationships with utility companies to offer financial incentives (direct or rate) based on the energy saving features of AAC homes.

Education is needed to increase awareness of AAC construction and to teach consumers why they should not be satisfied with lumber construction. Education programs should emphasize the superior benefits of energy efficiency, durability, disaster resistance, and pest resistance as primary reasons to prefer AAC construction over lumber. A sensitive balance is necessary to foster relationships with builders that currently rely heavily on lumber construction until they are fully integrated with AAC construction.

A significant tool in educating consumers and builders is a clear and concise comparison addressing initial and long term costs, with interest and life cycle considerations. This cost comparison should be the focus of a national education program. This comparison needs to be compiled in a manner comprehensible to consumers, similar to the sample cost comparison in Appendix A.

Solicit support of the *Portland Cement Association* to author and support implementation of energy codes that recognize the energy efficiency benefits associated with AAC structures.

Provide architects and engineers with tools to facilitate use of AAC in designs. Success of the strategic plan may rely on development of "tools" to assist design and construction professionals and home buyers in adopting AAC as a conventional residential construction method. Such tools may include:

- design kits with mini scale blocks, panels, lintels, etc. that can easily be put together to determine constructability and feasibility
- AAC computer design software
- classroom curriculum for educational institutions
- curriculum for practicing architects and engineers

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Appendix A: Life Cycle Cost Comparison Analysis

Life Cycle Cost Comparison Analysis

	2x4 Lumber Stud (R-13)		8" AAC Block	
Capital Costs				
	Exterior Framing	$2.45 /SF*	Exterior Framing	$7.50 /SF*
	2x4 Lumber		Block	
	1/2" Plywood		Exterior Stucco	
	3 1/2" Insulation		Interior Stucco	
	Glue / Nails			
	Labor			
	Finishes		Finishes	
	Exterior Stucco	$2.50 /SF*	Included Above	
	Interior Sheetrock	$0.80 /SF*		
		$5.75 /SF*		$7.50 /SF*
	x1581 SF**	$9,090.75		$11,857.50
HVAC	4 ton Package	$6,000.00	3 ton Package	$4,500.00
	Subtotal	$15,090.75		$16,357.50
Monthly Mortgage ***		$100.35		$108.78
Annual Mortgage Payments		$1,204.24		$1,305.33
Annual Insurance Costs****		$348.00		$317.00
Annual Energy Costs*****		$1,524.00		$1,269.00
Annual Termite Costs******		$260.00		$0.00
Total Annual Costs		$3,336.24		$2,891.33

Annual Savings Using AAC **$444.91**

30 yr Mortgage Term Savings **$13,347.40**

* Gross Square Footage

** Based on 2000 SF (area) home approximately 33' x 60' (186 LF) with 8.5' high walls (1581 SF*). Assume both homes have 8" batt ceiling

*** $6.65 per thousand mortgaged (http://quicken.aol.com, May 20, 1998)

**** Insurance estimates courtesy of *USAA Insurance* (See Contact Index)

***** Energy cost figures (Sterling, 1993), using Southeastern (Atlanta) rates

****** Average termite estimates from *Orkin, Dixie, Bug-Off* (Atlanta area, 8/98) $800 treatment every 5 years with $100 per year inspection / maintenance

Capital Cost Estimates for 2x4 Stud Frame and AAC Frame (VanderWerf, 1995)

[illegible]

Appendix B: The Survey

Welcome!

to the Georgia Institute of Technology Residential Research Page!

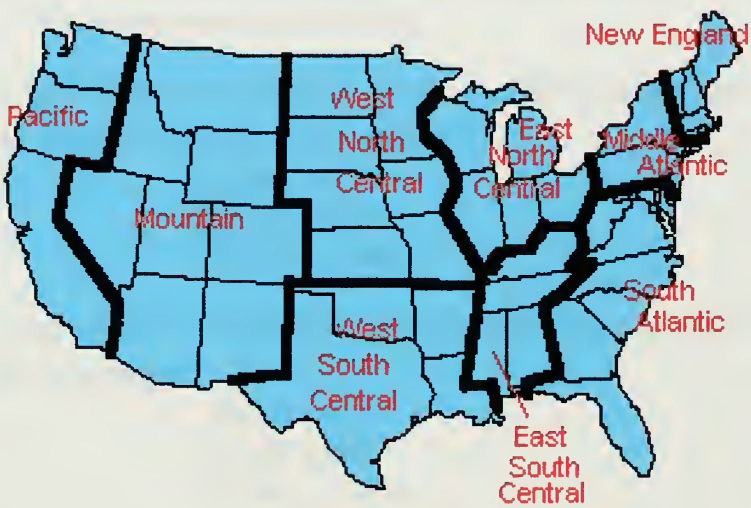
Yes, you can make a difference in the way homes are built in the U.S.!
We are conducting an economic feasibility study of **Innovative Construction Products** for residential exterior framing systems.

Your participation in this survey could change the way homes are built in the United States!

Please take a moment to answer the following 9 questions relative to your next residential purchase.

1. What region of the United States do you intend to purchase a home?

○ Pacific
○ Mountain
○ West North Central
○ West South Central
○ East North Central
○ East South Central
○ New England
○ Middle Atlantic
○ South Atlantic



2. What size home do you intend to purchase?

○ Less than 1,000 square feet
○ 1,000-1,499 square feet
○ 1,500-1,799 square feet
○ 1,800-2,999 square feet
○ 3,000 square feet or more

3. What price home do you intend to purchase?

○ Less than $75,000
○ $75,000-$124,999
○ $125,000-$199,999
○ $200,000-$349,999
○ $350,000 and over

4. What number purchase will your next home be?
- ○ First (1)
- ○ Second (2)
- ○ Third (3)
- ○ Fourth (4)
- ○ Fifth or Greater (5+)

5. Please rank the following 6 characteristics of your home on their importance to you.
1=Most Important 6=Least Important

☐ Appearance	☐ Durability
☐ Maintenance Cost	☐ Energy Efficiency
☐ Disaster Resistance	☐ Initial Cost

For questions #6 Through #8, the following guidance is provided:
30 year fixed rate mortgage
Interest rate of 7.00% (National Average 5/98, see link following data submission)
Monthly mortgage payment is $6.65 per $1,000 (See mortgage calculator link following data submission)

6. How much more would you be willing to spend for a home offering **superior resistance to fire and natural disasters** such as hurricanes?
- ○ None
- ○ Less than $1500
- ○ $1500-$2999
- ○ $3000-$4499
- ○ $4500-$5999
- ○ $6000 or more

7. How much more would you be willing to spend for a home offering **superior resistance to Termite and Pest damage**?
- ○ None
- ○ Less than $1500
- ○ $1500-$2999
- ○ $3000-$4499
- ○ $4500-$5999
- ○ $6000 or more

8. How much more would you be willing to spend for a **more energy efficient home** offering 15-20% savings in energy costs per year?
- ○ None
- ○ Less than $1500
- ○ $1500-$2999
- ○ $3000-$4499
- ○ $4500-$5999
- ○ $6000 or more

9. What is the minimum number of years you would expect to break even on the premium upgrade costs addressed above?
- ○ Less than 3 years
- ○ 3-5 years
- ○ 6-9 years
- ○ 10-12 years
- ○ 13-15 years
- ○ More than 15 years

Please write any comments here (Optional).

Please submit data first, then page back to go to links! Submit Reset Form

Related links:

- Visit The **Southface** Homepage! www.southface.org Southface is an organization dedicated to Energy, Environmental, and Sustainability issues of your home!
- Research Coordinator: gt7768d@prism.gatech.edu or My Georgia Tech Home Page
- Mortgage Calculators: Site I, Site II
- Mortgage Interest Rates: current rate averages

Appendix C: Survey Data Sheets

Characteristic Rankings

Characteristic Ranking by Home Cost	<$75K	$75-124K	$125-199K	$200-349K	>$350K
Appearance	4.83	3.67	3.02	2.89	2.71
Maintenance Cost	2.7	3.52	3.79	3.93	3.5
Disaster Resistance	4.65	4.88	5.06	4.86	4.43
Durability	2.91	3.06	3.28	3.21	3.46
Energy Efficiency	3.09	3.32	3.19	3.2	4.11
Initial Cost	2.83	2.58	2.6	2.91	2.79

Characteristic Ranking by Home Number	1st	2nd	3rd	4th	5th+
Appearance	3.33	3.16	3.27	3.03	2.72
Maintenance Cost	3.49	3.99	3.72	3.69	3.14
Disaster Resistance	4.62	4.96	5.12	4.86	4.94
Durability	2.96	3.02	3.32	3.45	3.9
Energy Efficiency	3.78	3.31	2.8	3.01	3.84
Initial Cost	2.68	2.57	2.75	2.96	2.46

Characteristic Rankings and Spending Patterns Based on Region

Region

Appearance	ENC	%	Score	ESC	%	Score	MA	%	Score	MTN	%	Score	NE	%	Score	P	%	Score
1	6	9.8%	6.00	16	15.8%	16.00	20	25.6%	20.00	16	43.2%	16.00	13	25.0%	13.00	9	18.0%	9.00
2	9	14.8%	18.00	17	16.8%	34.00	25	32.1%	50.00	3	8.1%	6.00	7	13.5%	14.00	6	12.0%	12.00
3	9	14.8%	27.00	14	13.9%	42.00	9	11.5%	27.00	6	16.2%	18.00	5	9.6%	15.00	17	34.0%	51.00
4	9	14.8%	36.00	21	20.8%	84.00	10	12.8%	40.00	7	18.9%	28.00	7	13.5%	28.00	8	16.0%	32.00
5	14	23.0%	70.00	19	18.8%	95.00	9	11.5%	45.00	2	5.4%	10.00	6	11.5%	30.00	1	2.0%	5.00
6	14	23.0%	84.00	14	13.9%	84.00	5	6.4%	30.00	3	8.1%	18.00	14	26.9%	84.00	9	18.0%	54.00
	61		3.95	101		3.51	78		2.72	37		2.59	52		3.54	50		3.26

Maintenance	ENC	%	Score	ESC	%	Score	MA	%	Score	MTN	%	Score	NE	%	Score	P	%	Score
1	4	6.6%	4.00	5	5.0%	5.00	14	17.9%	14.00	2	5.4%	2.00	3	5.8%	3.00	5	10.0%	5.00
2	8	13.1%	16.00	15	14.9%	30.00	7	9.0%	14.00	6	16.2%	12.00	12	23.1%	24.00	7	14.0%	14.00
3	7	11.5%	21.00	14	13.9%	42.00	26	33.3%	78.00	6	16.2%	18.00	7	13.5%	21.00	4	8.0%	12.00
4	26	42.6%	104.00	28	27.7%	112.00	12	15.4%	48.00	11	29.7%	44.00	16	30.8%	64.00	11	22.0%	44.00
5	10	16.4%	50.00	19	18.8%	95.00	15	19.2%	75.00	10	27.0%	50.00	11	21.2%	55.00	18	36.0%	90.00
6	6	9.8%	36.00	20	19.8%	120.00	4	5.1%	24.00	2	5.4%	12.00	3	5.8%	18.00	5	10.0%	30.00
	61		3.79	101		4.00	78		3.24	37		3.73	52		3.56	50		3.90

Disaster	ENC	%	Score	ESC	%	Score	MA	%	Score	MTN	%	Score	NE	%	Score	P	%	Score
1	5	8.2%	5.00	6	5.9%	6.00	2	2.6%	2.00	1	2.7%	1.00	1	1.9%	1.00	3	6.0%	3.00
2	2	3.3%	4.00	8	7.9%	16.00	7	9.0%	14.00	2	5.4%	4.00	0	0.0%	0.00	2	4.0%	4.00
3	0	0.0%	0.00	8	7.9%	24.00	3	3.8%	9.00	1	2.7%	3.00	10	19.2%	30.00	0	0.0%	0.00
4	5	8.2%	20.00	12	11.9%	48.00	12	15.4%	48.00	4	10.8%	16.00	13	25.0%	52.00	2	4.0%	8.00
5	15	24.6%	75.00	17	16.8%	85.00	3	3.8%	15.00	5	13.5%	25.00	11	21.2%	55.00	19	38.0%	95.00
6	34	55.7%	204.00	50	49.5%	300.00	51	65.4%	306.00	24	64.9%	144.00	17	32.7%	102.00	24	48.0%	144.00
	61		5.05	101		4.74	78		5.05	37		5.22	52		4.62	50		5.08

Durability	ENC	%	Score	ESC	%	Score	MA	%	Score	MTN	%	Score	NE	%	Score	P	%	Score
1	7	11.5%	7.00	16	15.8%	16.00	11	14.1%	11.00	8	21.6%	8.00	13	25.0%	13.00	4	8.0%	4.00
2	15	24.6%	30.00	15	14.9%	30.00	12	15.4%	24.00	6	16.2%	12.00	11	21.2%	22.00	7	14.0%	14.00
3	18	29.5%	54.00	25	24.8%	75.00	16	20.5%	48.00	7	18.9%	21.00	5	9.6%	15.00	17	34.0%	51.00
4	9	14.8%	36.00	12	11.9%	48.00	19	24.4%	76.00	4	10.8%	16.00	5	9.6%	20.00	13	26.0%	52.00
5	10	16.4%	50.00	28	27.7%	140.00	18	23.1%	90.00	11	29.7%	55.00	14	26.9%	70.00	6	12.0%	30.00
6	2	3.3%	12.00	5	5.0%	30.00	2	2.6%	12.00	1	2.7%	6.00	4	7.7%	24.00	3	6.0%	18.00
	61		3.10	101		3.36	78		3.35	37		3.19	52		3.15	50		3.38

Energy	ENC	%	Score	ESC	%	Score	MA	%	Score	MTN	%	Score	NE	%	Score	P	%	Score
1	27	44.3%	27.00	28	27.7%	28.00	0	0.0%	0.00	3	8.1%	3.00	10	19.2%	10.00	8	16.0%	8.00
2	7	11.5%	14.00	22	21.8%	44.00	11	14.1%	22.00	1	2.7%	2.00	16	30.8%	32.00	14	28.0%	28.00
3	15	24.6%	45.00	18	17.8%	54.00	13	16.7%	39.00	14	37.8%	42.00	6	11.5%	18.00	7	14.0%	21.00
4	7	11.5%	28.00	17	16.8%	68.00	19	24.4%	76.00	9	24.3%	36.00	11	21.2%	44.00	12	24.0%	48.00
5	5	8.2%	25.00	11	10.9%	55.00	25	32.1%	125.00	7	18.9%	35.00	8	15.4%	40.00	2	4.0%	10.00
6	0	0.0%	0.00	5	5.0%	30.00	10	12.8%	60.00	3	8.1%	18.00	1	1.9%	6.00	7	14.0%	42.00
	61		2.28	101		2.76	78		4.13	37		3.68	52		2.88	50		3.14

Cost	ENC	%	Score	ESC	%	Score	MA	%	Score	MTN	%	Score	NE	%	Score	P	%	Score
1	12	19.7%	12.00	30	29.7%	30.00	34	43.6%	34.00	7	18.9%	7.00	12	23.1%	12.00	21	42.0%	21.00
2	22	36.1%	44.00	22	21.8%	44.00	16	20.5%	32.00	19	51.4%	38.00	8	15.4%	16.00	14	28.0%	28.00
3	10	16.4%	30.00	24	23.8%	72.00	11	14.1%	33.00	3	8.1%	9.00	18	34.6%	54.00	5	10.0%	15.00
4	3	4.9%	12.00	11	10.9%	44.00	5	6.4%	20.00	2	5.4%	8.00	1	1.9%	4.00	4	8.0%	16.00
5	8	13.1%	40.00	7	6.9%	35.00	7	9.0%	35.00	2	5.4%	10.00	2	3.8%	10.00	4	8.0%	20.00
6	6	9.8%	36.00	7	6.9%	42.00	5	6.4%	30.00	4	10.8%	24.00	11	21.2%	66.00	2	4.0%	12.00
	61		2.85	101		2.64	78		2.36	37		2.59	52		3.12	50		2.24

Characteristic Rankings and Spending Patterns Based on Region

SA	%	Score	WNC	%	Score	WSC	%	Score	Total	%	Score
60	29 0%	60 00	1	2.9%	1.00	16	22.2%	16.00	157	22.7%	157.00
44	21 3%	88 00	11	31.4%	22.00	20	27.8%	40 00	142	20 5%	284.00
28	13 5%	84 00	6	17 1%	18 00	11	15.3%	33 00	105	15 2%	315.00
21	10.1%	84 00	5	14 3%	20.00	10	13.9%	40.00	98	14 1%	392.00
27	13.0%	135 00	5	14.3%	25.00	4	5.6%	20.00	87	12.6%	435.00
27	13.0%	162 00	7	20 0%	42.00	11	15.3%	66.00	104	15 0%	624.00
207		2.96	35		3.66	72		2.99	693		3.18

SA	%	Score	WNC	%	Score	WSC	%	Score	Total	%	Score
14	6 8%	14 00	3	8 6%	3.00	0	0 0%	0 00	50	7 2%	50 00
30	14 5%	60 00	2	5 7%	4 00	8	11 1%	16 00	95	13 7%	190 00
48	23 2%	144 00	6	17.1%	18 00	11	15.3%	33.00	129	18.6%	387.00
71	34 3%	284 00	12	34.3%	48 00	33	45.8%	132 00	220	31 7%	880 00
30	14 5%	150 00	6	17.1%	30 00	10	13 9%	50 00	129	18 6%	645 00
14	6 8%	84 00	6	17 1%	36 00	10	13 9%	60 00	70	10 1%	420.00
207		3 56	35		3.97	72		4.04	693		3.71

SA	%	Score	WNC	%	Score	WSC	%	Score	Total	%	Score
13	6.3%	13.00	1	2 9%	1.00	5	6 9%	5.00	37	5.3%	37.00
13	6 3%	26 00	1	2 9%	2 00	7	9 7%	14.00	42	6 1%	84.00
7	3 4%	21 00	2	5 7%	6 00	5	6 9%	15 00	36	5 2%	108 00
16	7 7%	64 00	1	2 9%	4 00	3	4.2%	12 00	68	9 8%	272 00
40	19 3%	200 00	11	31 4%	55 00	21	29 2%	105 00	142	20 5%	710 00
118	57 0%	708 00	19	54 3%	114 00	31	43 1%	186 00	368	53 1%	2208 00
207		4 99	35		5.20	72		4.68	693		4.93

SA	%	Score	WNC	%	Score	WSC	%	Score	Total	%	Score
43	20 8%	43 00	2	5 7%	2.00	11	15.3%	11.00	115	16.6%	115.00
37	17.9%	74 00	14	40 0%	28 00	17	23.6%	34.00	134	19 3%	268.00
40	19 3%	120 00	5	14 3%	15 00	13	18 1%	39 00	146	21 1%	438 00
37	17 9%	148 00	9	25 7%	36 00	8	8 3%	24 00	114	16 5%	456 00
45	21 7%	225 00	2	5 7%	10 00	22	30 6%	110 00	156	22 5%	780 00
5	2 4%	30.00	3	8 6%	18.00	3	4.2%	18.00	28	4 0%	168 00
207		3 09	35		3 11	72		3 28	693		3 21

SA	%	Score	WNC	%	Score	WSC	%	Score	Total	%	Score
16	7 7%	16.00	8	22.9%	8.00	8	11.1%	8.00	108	15.6%	108.00
33	15.9%	66 00	9	25 7%	18.00	9	12.5%	18.00	122	17.6%	244 00
54	26 1%	162 00	7	20.0%	21.00	30	41 7%	90.00	164	23.7%	492.00
46	22 2%	184 00	4	11.4%	16.00	11	15.3%	44.00	136	19 6%	544.00
41	19 8%	205 00	7	20 0%	35 00	7	9 7%	35.00	113	16.3%	565.00
17	8 2%	102 00	0	0.0%	0.00	7	9 7%	42 00	50	7.2%	300.00
207		3.55	35		2.80	72		3.29	693		3.25

SA	%	Score	WNC	%	Score	WSC	%	Score	Total	%	Score
61	29.5%	61.00	20	57.1%	20.00	32	44.4%	32.00	229	33 0%	229.00
50	24 2%	100.00	0	0.0%	0 00	11	15.3%	22.00	162	23.4%	324.00
30	14 5%	90 00	9	25.7%	27.00	2	2 8%	6 00	112	16 2%	336.00
16	7 7%	64 00	2	5.7%	8 00	9	12 5%	36 00	53	7 6%	212.00
24	11 6%	120.00	4	11.4%	20.00	8	11.1%	40.00	66	9 5%	330 00
26	12.6%	156.00	0	0.0%	0.00	10	13.9%	60.00	71	10.2%	426.00
207		2.86	35		2.14	72		2.72	693		2.68

Characteristic Rankings and Spending Patterns Based on Region

Natural Disaster Pay	ENC	%	ESC	%	MA	%	MTN	%	NE	%	P	%
None	5	8.2%	3	3.0%	7	9.0%	0	0.0%	4	7.7%	1	2.0%
LT1500	8	13.1%	15	14.9%	22	28.2%	2	5.4%	0	0.0%	4	8.0%
1500-2999	23	37.7%	26	25.7%	15	19.2%	8	21.6%	19	36.5%	17	34.0%
3000-4499	22	36.1%	34	33.7%	14	17.9%	17	45.9%	16	30.8%	12	24.0%
4500-5999	1	1.6%	14	13.9%	10	12.8%	3	8.1%	10	19.2%	11	22.0%
GT6000	2	3.3%	9	8.9%	10	12.8%	7	18.9%	3	5.8%	5	10.0%
	61		101		78		37		52		50	

Pest Pay	ENC	%	ESC	%	MA	%	MTN	%	NE	%	P	%
None	3	4.9%	1	1.0%	6	7.7%	2	5.4%	3	5.8%	3	6.0%
LT1500	26	42.6%	25	24.8%	26	33.3%	10	27.0%	22	42.3%	12	24.0%
1500-2999	21	34.4%	43	42.6%	18	23.1%	18	48.6%	18	34.6%	17	34.0%
3000-4499	7	11.5%	23	22.8%	17	21.8%	3	8.1%	9	17.3%	12	24.0%
4500-5999	2	3.3%	7	6.9%	7	9.0%	0	0.0%	0	0.0%	2	4.0%
GT6000	2	3.3%	2	2.0%	4	5.1%	4	10.8%	0	0.0%	4	8.0%
	61		101		78		37		52		50	

Energy Efficient Pay	ENC	%	ESC	%	MA	%	MTN	%	NE	%	P	%
None	0	0.0%	0	0.0%	2	2.6%	4	10.8%	3	5.8%	1	2.0%
LT1500	7	11.5%	17	16.8%	7	9.0%	3	8.1%	4	7.7%	6	12.0%
1500-2999	16	26.2%	36	35.6%	21	26.9%	2	5.4%	26	50.0%	15	30.0%
3000-4499	31	50.8%	30	29.7%	23	29.5%	13	35.1%	16	30.8%	17	34.0%
4500-5999	5	8.2%	11	10.9%	18	23.1%	9	24.3%	3	5.8%	6	12.0%
GT6000	2	3.3%	7	6.9%	7	9.0%	6	16.2%	0	0.0%	5	10.0%
	61		101		78		37		52		50	

Payback	ENC	%	ESC	%	MA	%	MTN	%	NE	%	P	%
LT 3yr	2	3.3%	3	3.0%	8	10.3%	4	10.8%	2	3.8%	7	14.0%
3-5yr	19	31.1%	37	36.6%	37	47.4%	8	21.6%	22	42.3%	17	34.0%
6-9yr	15	24.6%	29	28.7%	21	26.9%	12	32.4%	8	15.4%	9	18.0%
10-12yr	21	34.4%	22	21.8%	7	9.0%	11	29.7%	18	34.6%	14	28.0%
13-15yr	4	6.6%	6	5.9%	5	6.4%	1	2.7%	2	3.8%	2	4.0%
GT 15yr	0	0.0%	4	4.0%	0	0.0%	1	2.7%	0	0.0%	1	2.0%
	61		101		78		37		52		50	

SA	%	WNC	%	WSC	%	Total	%
7	3 4%	2	5.7%	4	5.6%	33	4.8%
28	13.5%	5	14 3%	4	5 6%	88	12.7%
82	39 6%	15	42.9%	20	27.8%	225	32.5%
52	25 1%	4	11.4%	29	40.3%	200	28.9%
24	11 6%	8	22.9%	8	11.1%	89	12.8%
14	6 8%	1	2.9%	7	9.7%	58	8.4%
207		35		72		693	

SA	%	WNC	%	WSC	%	Total	%
7	3 4%	4	11.4%	14	19.4%	43	6.2%
56	27 1%	10	28 6%	12	16 7%	199	28.7%
96	46 4%	12	34 3%	23	31 9%	266	38.4%
31	15 0%	5	14 3%	9	12 5%	116	16.7%
9	4 3%	4	11.4%	9	12 5%	40	5.8%
8	3 9%	0	0.0%	5	6 9%	29	4 2%
207		35		72		693	

SA	%	WNC	%	WSC	%	Total	%
0	0 0%	2	5.7%	2	2 8%	14	2.0%
33	15 9%	7	20.0%	6	8.3%	90	13.0%
74	35.7%	11	31.4%	21	29.2%	222	32 0%
60	29 0%	10	28 6%	26	36.1%	226	32 6%
29	14 0%	4	11 4%	11	15 3%	96	13 9%
11	5 3%	1	2 9%	6	8 3%	45	6 5%
207		35		72		693	

SA	%	WNC	%	WSC	%	Total	%
5	2 4%	6	17 1%	0	0.0%	37	5.3%
68	32 9%	6	17 1%	21	29 2%	235	33 9%
84	40 6%	13	37 1%	22	30 6%	213	30.7%
37	17 9%	10	28.6%	27	37.5%	167	24.1%
10	4 8%	0	0 0%	0	0 0%	30	4 3%
3	1 4%	0	0 0%	2	2 8%	11	1 6%
207		35		72		693	

Characteristic Rankings and Spending Patterns Based on Cost of Home

Price of Home

Appearance	LT $75	%	Score	$75-124K	%	Score	$125-199K	%	Score	$200-349K	%	Score	GT $350K	%	Score	Total	%	Score
1	2	8.7%	2.00	29	18.7%	29.00	79	24.2%	79.00	37	23.1%	37.00	10	35.7%	10.00	157	22.7%	157.00
2	0	0.0%	0.00	22	14.2%	44.00	82	25.1%	164.00	34	21.3%	68.00	4	14.3%	8.00	142	20.5%	284.00
3	2	8.7%	6.00	16	10.3%	48.00	42	12.8%	126.00	37	23.1%	111.00	8	28.6%	24.00	105	15.2%	315.00
4	3	13.0%	12.00	24	15.5%	96.00	45	13.8%	180.00	26	16.3%	104.00	0	0.0%	0.00	98	14.1%	392.00
5	5	21.7%	25.00	32	20.6%	160.00	35	10.7%	175.00	13	8.1%	65.00	2	7.1%	10.00	87	12.6%	435.00
6	11	47.8%	66.00	32	20.6%	192.00	44	13.5%	264.00	13	8.1%	78.00	4	14.3%	24.00	104	15.0%	624.00
	23		4.83	155		3.67	327		3.02	160		2.89	28		2.71	693		3.18

Maintenance	LT $75	%	Score	$75-124K	%	Score	$125-199K	%	Score	$200-349K	%	Score	GT $350K	%	Score	Total	%	Score
1	9	39.1%	9.00	10	6.5%	10.00	21	6.4%	21.00	8	5.0%	8.00	2	7.1%	2.00	50	7.2%	50.00
2	3	13.0%	6.00	25	16.1%	50.00	35	10.7%	70.00	23	14.4%	46.00	9	32.1%	18.00	95	13.7%	190.00
3	2	8.7%	6.00	38	24.5%	114.00	60	18.3%	180.00	28	17.5%	84.00	1	3.6%	3.00	129	18.6%	387.00
4	5	21.7%	20.00	48	31.0%	192.00	118	36.1%	472.00	42	26.3%	168.00	7	25.0%	28.00	220	31.7%	880.00
5	3	13.0%	15.00	25	16.1%	125.00	62	19.0%	310.00	32	20.0%	160.00	7	25.0%	35.00	129	18.6%	645.00
6	1	4.3%	6.00	9	5.8%	54.00	31	9.5%	186.00	27	16.9%	162.00	2	7.1%	12.00	70	10.1%	420.00
	23		2.70	155		3.52	327		3.79	160		3.93	28		3.50	693		3.71

Disaster	LT $75	%	Score	$75-124K	%	Score	$125-199K	%	Score	$200-349K	%	Score	GT $350K	%	Score	Total	%	Score
1	2	8.7%	2.00	8	5.2%	8.00	15	4.6%	15.00	11	6.9%	11.00	1	3.6%	1.00	37	5.3%	37.00
2	0	0.0%	0.00	17	11.0%	34.00	14	4.3%	28.00	7	4.4%	14.00	4	14.3%	8.00	42	6.1%	84.00
3	2	8.7%	6.00	3	1.9%	9.00	25	7.6%	75.00	5	3.1%	15.00	1	3.6%	3.00	36	5.2%	108.00
4	4	17.4%	16.00	12	7.7%	48.00	22	6.7%	88.00	23	14.4%	92.00	7	25.0%	28.00	68	9.8%	272.00
5	7	30.4%	35.00	33	21.3%	165.00	58	17.7%	290.00	38	23.8%	190.00	6	21.4%	30.00	142	20.5%	710.00
6	8	34.8%	48.00	82	52.9%	492.00	193	59.0%	1158.00	76	47.5%	456.00	9	32.1%	54.00	368	53.1%	2208.00
	23		4.65	155		4.88	327		5.06	160		4.86	28		4.43	693		4.93

Durability	LT $75	%	Score	$75-124K	%	Score	$125-199K	%	Score	$200-349K	%	Score	GT $350K	%	Score	Total	%	Score
1	0	0.0%	0.00	31	20.0%	31.00	51	15.6%	51.00	31	19.4%	31.00	2	7.1%	2.00	115	16.6%	115.00
2	10	43.5%	20.00	36	23.2%	72.00	53	16.2%	106.00	29	18.1%	58.00	6	21.4%	12.00	134	19.3%	268.00
3	7	30.4%	21.00	24	15.5%	72.00	80	24.5%	240.00	29	18.1%	87.00	6	21.4%	18.00	146	21.1%	438.00
4	4	17.4%	16.00	29	18.7%	116.00	50	15.3%	200.00	24	15.0%	96.00	7	25.0%	28.00	114	16.5%	456.00
5	2	8.7%	10.00	27	17.4%	135.00	82	25.1%	410.00	40	25.0%	200.00	5	17.9%	25.00	156	22.5%	780.00
6	0	0.0%	0.00	8	5.2%	48.00	11	3.4%	66.00	7	4.4%	42.00	2	7.1%	12.00	28	4.0%	168.00
	23		2.91	155		3.06	327		3.28	160		3.21	28		3.46	693		3.21

Energy	LT $75	%	Score	$75-124K	%	Score	$125-199K	%	Score	$200-349K	%	Score	GT $350K	%	Score	Total	%	Score
1	2	8.7%	2.00	21	13.5%	21.00	63	19.3%	63.00	21	13.1%	21.00	1	3.6%	1.00	108	15.6%	108.00
2	8	34.8%	16.00	23	14.8%	46.00	50	15.3%	100.00	39	24.4%	78.00	2	7.1%	4.00	122	17.6%	244.00
3	5	21.7%	15.00	43	27.7%	129.00	72	22.0%	216.00	36	22.5%	108.00	7	25.0%	21.00	163	23.5%	489.00
4	3	13.0%	12.00	34	21.9%	136.00	65	19.9%	260.00	28	17.5%	112.00	7	25.0%	28.00	137	19.8%	548.00
5	4	17.4%	20.00	22	14.2%	110.00	59	18.0%	295.00	23	14.4%	115.00	5	17.9%	25.00	113	16.3%	565.00
6	1	4.3%	6.00	12	7.7%	72.00	18	5.5%	108.00	13	8.1%	78.00	6	21.4%	36.00	50	7.2%	300.00
	23		3.09	155		3.32	327		3.19	160		3.20	28		4.11	693		3.25

Cost	LT $75	%	Score	$75-124K	%	Score	$125-199K	%	Score	$200-349K	%	Score	GT $350K	%	Score	Total	%	Score
1	8	34.8%	8.00	56	36.1%	56.00	101	30.9%	101.00	52	32.5%	52.00	12	42.9%	12.00	229	33.0%	229.00
2	2	8.7%	4.00	32	20.6%	64.00	97	29.7%	194.00	28	17.5%	56.00	3	10.7%	6.00	162	23.4%	324.00
3	5	21.7%	15.00	30	19.4%	90.00	47	14.4%	141.00	25	15.6%	75.00	5	17.9%	15.00	112	16.2%	336.00
4	4	17.4%	16.00	8	5.2%	32.00	24	7.3%	96.00	17	10.6%	68.00	0	0.0%	0.00	53	7.6%	212.00
5	2	8.7%	10.00	16	10.3%	80.00	31	9.5%	155.00	14	8.8%	70.00	3	10.7%	15.00	66	9.5%	330.00
6	2	8.7%	12.00	13	8.4%	78.00	27	8.3%	162.00	24	15.0%	144.00	5	17.9%	30.00	71	10.2%	426.00
	23		2.83	155		2.58	327		2.60	160		2.91	28		2.79	693		2.68

Characteristic Rankings and Spending Patterns Based on Cost of Home

Natural Disaster Pay	LT $75	%	$75-124K	%	$125-199K	%	$200-349K	%	GT $350K	%	Total	%
None	7	30.4%	0	0.0%	20	6.1%	5	3.1%	1	3 6%	33	4 8%
LT1500	2	8.7%	26	16.8%	37	11.3%	19	11.9%	4	14 3%	88	12 7%
1500-2999	9	39.1%	47	30.3%	113	34.6%	50	31.3%	6	21 4%	225	32 5%
3000-4499	2	8.7%	58	37.4%	91	27.8%	44	27.5%	5	17.9%	200	28 9%
4500-5999	1	4.3%	18	11.6%	47	14.4%	21	13.1%	2	7.1%	89	12 8%
GT6000	2	8.7%	6	3.9%	19	5.8%	21	13.1%	10	35 7%	58	8 4%
	23		155		327		160		28		693	

Pest Pay	LT $75	%	$75-124K	%	$125-199K	%	$200-349K	%	GT $350K	%	Total	%
None	2	8.7%	8	5.2%	21	6.4%	9	5 6%	3	10 7%	43	6 2%
LT1500	10	43.5%	39	25.2%	100	30.6%	44	27.5%	6	21.4%	199	28.7%
1500-2999	10	43.5%	67	43.2%	132	40 4%	50	31 3%	7	25 0%	266	38 4%
3000-4499	1	4.3%	31	20.0%	43	13.1%	34	21.3%	7	25 0%	116	16.7%
4500-5999	0	0.0%	10	6.5%	17	5.2%	12	7 5%	1	3 6%	40	5 8%
GT6000	0	0.0%	0	0 0%	14	4.3%	11	6.9%	4	14 3%	29	4 2%
	23		155		327		160		28		693	

Energy Efficient Pay	LT $75	%	$75-124K	%	$125-199K	%	$200-349K	%	GT $350K	%	Total	%
None	2	8.7%	2	1.3%	4	1.2%	2	1.3%	4	14 3%	14	2 0%
LT1500	6	26 1%	17	11.0%	39	11.9%	22	13.8%	6	21 4%	90	13.0%
1500-2999	14	60.9%	50	32.3%	116	35.5%	40	25.0%	2	7.1%	222	32.0%
3000-4499	1	4 3%	47	30.3%	124	37.9%	45	28.1%	9	32.1%	226	32 6%
4500-5999	0	0 0%	36	23 2%	27	8.3%	33	20.6%	0	0 0%	96	13 9%
GT6000	0	0 0%	3	1.9%	17	5 2%	18	11.3%	7	25 0%	45	6 5%
	23		155		327		160		28		693	

Payback	LT $75	%	$75-124K	%	$125-199K	%	$200-349K	%		%	Total	%
LT 3yr	2	8 7%	7	4.5%	10	3.1%	14	8 8%	4	14 3%	37	5 3%
3-5yr	5	21 7%	60	38.7%	112	34.3%	47	29 4%	11	39.3%	235	33 9%
6-9yr	11	47 8%	38	24 5%	115	35 2%	40	25 0%	9	32 1%	213	30 7%
10-12yr	4	17.4%	42	27.1%	83	25 4%	37	23 1%	1	3 6%	167	24 1%
13-15yr	0	0 0%	8	5.2%	6	1.8%	14	8 8%	2	7 1%	30	4 3%
GT 15yr	1	4 3%	0	0 0%	1	0 3%	8	5.0%	1	3 6%	11	1 6%
	23		155		327		160		28		693	

Characteristic Rankings and Spending Patterns Based on Number of House

Number of Home Appearance	FIRST	%	Score	SECOND	%	Score	THIRD	%	Score	FOURTH	%	Score	FIFTH	%	Score	Total	%	Score
1	30	22.1%	30.00	53	24.5%	53.00	46	20.9%	46.00	19	26.8%	19.00	9	18.0%	9.00	157	22.7%	157.00
2	26	19.1%	52.00	44	20.4%	88.00	47	21.4%	94.00	12	16.9%	24.00	13	26.0%	26.00	142	20.5%	284.00
3	17	12.5%	51.00	27	12.5%	81.00	27	12.3%	81.00	15	21.1%	45.00	19	38.0%	57.00	105	15.2%	315.00
4	19	14.0%	76.00	32	14.8%	128.00	37	16.8%	148.00	6	8.5%	24.00	4	8.0%	16.00	98	14.1%	392.00
5	20	14.7%	100.00	27	12.5%	135.00	27	12.3%	135.00	11	15.5%	55.00	2	4.0%	10.00	87	12.6%	435.00
6	24	17.6%	144.00	33	15.3%	198.00	36	16.4%	216.00	8	11.3%	48.00	3	6.0%	18.00	104	15.0%	624.00
	136		3.33	216		3.16	220		3.27	71		3.03	50		2.72	693		3.18

Maintenance	FIRST	%	Score	SECOND	%	Score	THIRD	%	Score	FOURTH	%	Score	FIFTH	%	Score	Total	%	Score
1	13	9.6%	13.00	13	6.0%	13.00	12	5.5%	12.00	6	8.5%	6.00	6	12.0%	6.00	50	7.2%	50.00
2	28	19.1%	52.00	18	8.3%	36.00	30	13.6%	60.00	11	15.5%	22.00	10	20.0%	20.00	95	13.7%	190.00
3	31	22.8%	93.00	34	15.7%	102.00	38	17.3%	114.00	9	12.7%	27.00	17	34.0%	51.00	129	18.6%	387.00
4	24	17.6%	96.00	73	33.8%	292.00	88	40.0%	352.00	28	39.4%	112.00	7	14.0%	28.00	220	31.7%	880.00
5	32	23.5%	160.00	50	23.1%	250.00	32	14.5%	160.00	7	9.9%	35.00	8	16.0%	40.00	129	18.6%	645.00
6	10	7.4%	60.00	28	13.0%	168.00	20	9.1%	120.00	10	14.1%	60.00	2	4.0%	12.00	70	10.1%	420.00
	136		3.49	216		3.99	220		3.72	71		3.69	50		3.14	693		3.71

Disaster	FIRST	%	Score	SECOND	%	Score	THIRD	%	Score	FOURTH	%	Score	FIFTH	%	Score	Total	%	Score
1	8	5.9%	8.00	14	6.5%	14.00	10	4.5%	10.00	5	7.0%	5.00	0	0.0%	0.00	37	5.3%	37.00
2	14	10.3%	28.00	13	6.0%	26.00	5	2.3%	10.00	6	8.5%	12.00	4	8.0%	8.00	42	6.1%	84.00
3	10	7.4%	30.00	5	2.3%	15.00	13	5.9%	39.00	2	2.8%	6.00	6	12.0%	18.00	36	5.2%	108.00
4	22	16.2%	88.00	20	9.3%	80.00	15	6.8%	60.00	7	9.9%	28.00	4	8.0%	16.00	68	9.8%	272.00
5	18	13.2%	90.00	47	21.8%	235.00	54	24.5%	270.00	12	16.9%	60.00	11	22.0%	55.00	142	20.5%	710.00
6	64	47.1%	384.00	117	54.2%	702.00	123	55.9%	738.00	39	54.9%	234.00	25	50.0%	150.00	368	53.1%	2208.00
	136		4.62	216		4.96	220		5.12	71		4.86	50		4.94	693		4.93

Durability	FIRST	%	Score	SECOND	%	Score	THIRD	%	Score	FOURTH	%	Score	FIFTH	%	Score	Total	%	Score
1	33	24.3%	33.00	34	15.7%	34.00	34	15.5%	34.00	9	12.7%	9.00	5	10.0%	5.00	115	16.6%	115.00
2	27	19.9%	54.00	49	22.7%	98.00	37	16.8%	74.00	12	16.9%	24.00	9	18.0%	18.00	134	19.3%	268.00
3	20	14.7%	60.00	63	29.2%	189.00	46	20.9%	138.00	15	21.1%	45.00	2	4.0%	6.00	146	21.1%	438.00
4	26	19.1%	104.00	26	12.0%	104.00	41	18.6%	164.00	11	15.5%	44.00	10	20.0%	40.00	114	16.5%	456.00
5	29	21.3%	145.00	37	17.1%	185.00	51	23.2%	255.00	21	29.6%	105.00	18	36.0%	90.00	156	22.5%	780.00
6	1	0.7%	6.00	7	3.2%	42.00	11	5.0%	66.00	3	4.2%	18.00	6	12.0%	36.00	28	4.0%	168.00
	136		2.96	216		3.02	220		3.32	71		3.45	50		3.90	693		3.21

Energy	FIRST	%	Score	SECOND	%	Score	THIRD	%	Score	FOURTH	%	Score	FIFTH	%	Score	Total	%	Score
1	10	7.4%	10.00	29	13.4%	29.00	58	26.4%	58.00	8	11.3%	8.00	3	6.0%	3.00	108	15.6%	108.00
2	19	14.0%	38.00	28	13.0%	56.00	42	19.1%	84.00	24	33.8%	48.00	9	18.0%	18.00	122	17.6%	244.00
3	33	24.3%	99.00	62	28.7%	186.00	50	22.7%	150.00	15	21.1%	45.00	4	8.0%	12.00	164	23.7%	492.00
4	30	22.1%	120.00	48	22.2%	192.00	30	13.6%	120.00	10	14.1%	40.00	18	36.0%	72.00	136	19.6%	544.00
5	17	12.5%	85.00	41	19.0%	205.00	35	15.9%	175.00	11	15.5%	55.00	9	18.0%	45.00	113	16.3%	565.00
6	27	19.9%	162.00	8	3.7%	48.00	5	2.3%	30.00	3	4.2%	18.00	7	14.0%	42.00	50	7.2%	300.00
	136		3.78	216		3.31	220		2.80	71		3.01	50		3.84	693		3.25

Cost	FIRST	%	Score	SECOND	%	Score	THIRD	%	Score	FOURTH	%	Score	FIFTH	%	Score	Total	%	Score
1	45	33.1%	45.00	73	33.8%	73.00	60	27.3%	60.00	24	33.8%	24.00	27	54.0%	27.00	229	33.0%	229.00
2	26	19.1%	52.00	62	28.7%	124.00	63	28.6%	128.00	6	8.5%	12.00	5	10.0%	10.00	162	23.4%	324.00
3	25	18.4%	75.00	27	12.5%	81.00	43	19.5%	129.00	15	21.1%	45.00	2	4.0%	6.00	112	16.2%	336.00
4	14	10.3%	56.00	16	7.4%	64.00	7	3.2%	28.00	9	12.7%	36.00	7	14.0%	28.00	53	7.6%	212.00
5	19	14.0%	95.00	15	6.9%	75.00	21	9.5%	105.00	9	12.7%	45.00	2	4.0%	10.00	66	9.5%	330.00
6	7	5.1%	42.00	23	10.6%	138.00	26	11.8%	156.00	8	11.3%	48.00	7	14.0%	42.00	71	10.2%	426.00
	136		2.68	216		2.57	220		2.75	71		2.96	50		2.46	693		2.68

Characteristic Rankings and Spending Patterns Based on Number of House

Natural Disaster Pay	FIRST	%	SECOND	%	THIRD	%	FOURTH	%	FIFTH	%	Total	%
None	9	6.6%	12	5.6%	6	2.7%	2	2.8%	4	8.0%	33	4.8%
LT1500	21	15.4%	26	12.0%	29	13.2%	3	4.2%	9	18.0%	88	12.7%
1500-2999	42	30.9%	89	41.2%	60	27.3%	24	33.8%	10	20.0%	225	32.5%
3000-4499	36	26.5%	49	22.7%	83	37.7%	26	36.6%	6	12.0%	200	28.9%
4500-5999	18	13.2%	27	12.5%	30	13.6%	8	11.3%	6	12.0%	89	12.8%
GT6000	10	7.4%	13	6.0%	12	5.5%	8	11.3%	15	30.0%	58	8.4%
	136		216		220		71		50		693	

Pest Pay	FIRST	%	SECOND	%	THIRD	%	FOURTH	%	FIFTH	%	Total	%
None	12	8.8%	9	4.2%	18	8.2%	2	2.8%	2	4.0%	43	6.2%
LT1500	46	33.8%	57	26.4%	72	32.7%	13	18.3%	11	22.0%	199	28.7%
1500-2999	47	34.6%	99	45.8%	79	35.9%	30	42.3%	11	22.0%	266	38.4%
3000-4499	22	16.2%	36	16.7%	35	15.9%	15	21.1%	8	16.0%	116	16.7%
4500-5999	3	2.2%	9	4.2%	11	5.0%	9	12.7%	8	16.0%	40	5.8%
GT6000	6	4.4%	6	2.8%	5	2.3%	2	2.8%	10	20.0%	29	4.2%
	136		216		220		71		50		693	

Energy Efficient Pay	FIRST	%	SECOND	%	THIRD	%	FOURTH	%	FIFTH	%	Total	%
None	3	2.2%	5	2.3%	4	1.8%	2	2.8%	0	0.0%	14	2.0%
LT1500	27	19.9%	21	9.7%	21	9.5%	12	16.9%	9	18.0%	90	13.0%
1500-2999	37	27.2%	80	37.0%	81	36.8%	17	23.9%	7	14.0%	222	32.0%
3000-4499	43	31.6%	60	27.8%	84	38.2%	24	33.8%	15	30.0%	226	32.6%
4500-5999	19	14.0%	40	18.5%	19	8.6%	10	14.1%	8	16.0%	96	13.9%
GT6000	7	5.1%	10	4.6%	11	5.0%	6	8.5%	11	22.0%	45	6.5%
	136		216		220		71		50		693	

Payback	FIRST	%	SECOND	%	THIRD	%	FOURTH	%	FIFTH	%	Total	%
LT 3yr	8	5.9%	14	6.5%	11	5.0%	1	1.4%	3	6.0%	37	5.3%
3-5yr	53	39.0%	73	33.8%	77	35.0%	21	29.6%	11	22.0%	235	33.9%
6-9yr	41	30.1%	73	33.8%	51	23.2%	29	40.8%	19	38.0%	213	30.7%
10-12yr	26	19.1%	51	23.6%	70	31.8%	12	16.9%	8	16.0%	167	24.1%
13-15yr	5	3.7%	4	1.9%	11	5.0%	4	5.6%	6	12.0%	30	4.3%
GT 15yr	3	2.2%	1	0.5%	0	0.0%	4	5.6%	3	6.0%	11	1.6%
	136		216		220		71		50		693	

Ranking vs. Spending Comparisons

Disaster Ranking

Spend on Disaster	1	%	2	%	3	%	4	%	5	%	6	%	Total	%
None	1	2.7%	0	0.0%	0	0.0%	3	4.4%	4	2.8%	25	6.8%	33	4.8%
LT1500	1	2.7%	0	0.0%	1	2.8%	5	7.4%	21	14.8%	60	16.3%	88	12.7%
1500-2999	21	56.8%	12	28.6%	16	44.4%	16	23.5%	45	31.7%	115	31.3%	225	32.5%
3000-4599	2	5.4%	16	38.1%	6	16.7%	21	30.9%	46	32.4%	109	29.6%	200	28.9%
4500-5999	8	21.6%	11	26.2%	5	13.9%	13	19.1%	17	12.0%	35	9.5%	89	12.8%
GT6000	4	10.8%	3	7.1%	8	22.2%	10	14.7%	9	6.3%	24	6.5%	58	8.4%
	37		42		36		68		142		368		693	

Energy Efficiency Ranking

Spend on Efficiency	1	%	2	%	3	%	4	%	5	%	6	%	Total	%
None	4	3.7%	0	0.0%	3	1.8%	4	2.9%	2	1.8%	1	2.0%	14	2.0%
LT1500	2	1.9%	14	11.5%	15	9.1%	17	12.5%	22	19.5%	20	40.0%	90	13.0%
1500-2999	42	38.9%	47	38.5%	46	28.0%	30	22.1%	47	41.6%	10	20.0%	222	32.0%
3000-4599	48	44.4%	34	27.9%	51	31.1%	51	37.5%	29	25.7%	13	26.0%	226	32.6%
4500-5999	6	5.6%	19	15.6%	39	23.8%	18	13.2%	9	8.0%	5	10.0%	96	13.9%
GT6000	6	5.6%	8	6.6%	10	6.1%	16	11.8%	4	3.5%	1	2.0%	45	6.5%
	108		122		164		136		113		50		693	

Maintenance Cost Ranking

Spend on Pests	1	%	2	%	3	%	4	%	5	%	6	%	Total	%
None	7	14.0%	8	8.4%	6	4.7%	16	7.3%	3	2.3%	3	4.3%	43	6.2%
LT1500	21	42.0%	28	29.5%	32	24.8%	67	30.5%	30	23.3%	21	30.0%	199	28.7%
1500-2999	14	28.0%	38	40.0%	46	35.7%	91	41.4%	54	41.9%	23	32.9%	266	38.4%
3000-4599	6	12.0%	9	9.5%	27	20.9%	28	12.7%	24	18.6%	22	31.4%	116	16.7%
4500-5999	1	2.0%	6	6.3%	10	7.8%	13	5.9%	9	7.0%	1	1.4%	40	5.8%
GT6000	1	2.0%	6	6.3%	8	6.2%	5	2.3%	9	7.0%	0	0.0%	29	4.2%
	50		95		129		220		129		70		693	

Appendix D: Contact Index

Contact Index

Hebel	**www.hebel.com**			
Southeast	6600 Highlands Parkway		1(800)994-3235	(770)308-1500
	Smyrna, GA 30082			
		POC:	Bill Sutton	Vice President of Marketing-U.S. Operations
			Wayne Dawson	Director of Residential Sales
SouthCentral	4550 Sunbelt Drive		1(888)884-3235	
	Dallas, TX 75248			
		POC:	Courtney Hanson	
Ytong	**www.ytong.com**		(941)421-7000	
	1930 Lars Sjoborg Blvd.			
	Haines City, FL 33844			
NAHB				
Research Center			1(800)638-8556	
		POC:	Ed Hudson (x705)	Research Director
PCA				
	5420 Old Orchard Road		(847)966-6200	
	Skokie, IL 60077-1083			
		POC:	Jim Niehoff	Residential Program Manager
Elrick & Lavidge				
Marketing Research	1990 Lakeside Pkwy		(770)938-3233	
	Tucker, GA			
		POC:	Bill Salokar	
Decisive Technology	**www.decisive.com**			
			(650)528-4312	
Southface Energy Institute	**www.southface.org**			
	241 Pine Street		(404)872-3549	
	Atlanta, GA 30308			
		POC:	Mike Andreyuk	
USAA Insurance				
	9800 Fredericksburg Rd		1(800)531-8111	
	San Antonio, TX 78288-0001			

Contact Index

Quicktest				
	400 Ernest Barrett Pkwy		(770)423-0884	
	Marietta, GA 30066			
		POC:	Leigh	
Town Center Mall				
	400 Ernest Barrett Pkwy		(770)424-0915	
	Marietta, GA 30066			
		POC:	Skip Span	
Leaseplan, U.S. A.				
	180 Interstate North Pkwy (Suite 400)		1(800)457-8721	
	Atlanta, GA 30339			
Naval Air Station Atlanta				
	1000 Halsey Ave.		(770)919-6392	
	Marietta, GA 30060			
Colony Homes	**www.colonyhomes.com**			
	120 Colony Center Drive		(770)886-0090	
	Woodstock, GA 30188			
Pulte Homes				
	3100 Breckenridge Blvd, Suite 712		(770)381-3450	
	Duluth GA 30096			
Centex Homes				
	1150 Northmeadow Pkwy, Suite 100		(770)663-7670	
	Roswell, GA 30076			
		POC:	Rolan Rich	Manager
			Ted Brown	Purchasing
			Doug Stempowski	VP Marketing
Ryland Homes	**www.ryland.com**			
	1000 Holcomb Woods Pkwy, Suite 112A			
	Roswell, GA 30076			
		POC:	Matt Dooly	Architect
			Susan Byer	Marketing
Roller Compacted Concrete Dams	**rcc-dams@listserv.rediris.es**			
World Construction Set	**wcs@listserv.arizona.edu**			
Home Improvement	**homefix@vm3090.ege.edu.tr**			
Environmental Forum	**enfinf-l@nic.surfnet.nl**			

<u>Lieutenant Steven C. Bukoski</u>

<u>Civil Engineer Corps</u>

<u>United States Navy</u>

Lieutenant Bukoski began his Naval career as an enlisted nuclear power plant operator in July of 1981. Following his Naval Nuclear Power School training in Orlando, Florida, and prototype training in Ballston Spa, New York, he was assignment to the Reactor Department onboard the U.S.S. *Carl Vinson.* His primary duties during three 7 month deployments were nuclear power plant operations and maintenance. He later assumed new duties as Reactor Mechanical Division Work Center Supervisor, and as a Training Division instructor.

His next assignment, in May 1987, was to the Naval Nuclear Power "A" School for instructor duty where he directly supervised the training of more than 800 nuclear power school students. He was soon promoted to Chief Petty Officer, and in 1991 was accepted to the Enlisted Commissioning Program. He transferred to Prairie View A&M University in Houston, Texas, where he graduated with honors with a Civil Engineering Degree in December 1993.

Following commissioning as a Naval Civil Engineer Corps Officer, Lieutenant Bukoski was assigned as Assistant Public Works Officer at Naval Air Station Atlanta, Georgia. He was the Division Officer for a Seabee construction division and the principle assistant for maintenance, repair, planning, design, and support of facilities with a plant value of $105 million and a $3.2 million annual budget. In October 1996 he assumed additional duties as Assistant Resident Officer in Charge of Construction for Naval Facilities Engineering Command, Southern Division, Field Office Atlanta Area. As Project Manager he supervised (in a year's time) administration and execution of nine federal construction and repair contracts with a total value of $1.2 million. His varied experience within the four year tour provided insight to the problems associated with construction and maintenance of facilities. Even more so enlightening and important are the experiences of facility life cycle costs that are directly attributed to construction methods.

His latest assignment is to the Georgia Institute of Technology to pursue a Master's Degree in Construction Engineering and Management. His year long studies are dedicated to this research effort in hopes it will truly make a difference in the way residential construction is viewed in the United States. He strongly believes that innovative construction methods are essential to worldwide efforts to preserve natural resources and to protect the environment.

Lieutenant Bukoski is a certified Professional Engineer in the State of Georgia. He currently resides in Marietta, Georgia with his wife, Lori, and their two sons, Zachary and Sumner. Following graduation, he will administer federal construction contracts for Naval Facilities Command, Northern Division, at the Naval Shipyard in Philadelphia, Pennsylvania.